Hastings Business Law Journal

Volume 17
Number 1 *Winter 2021*

Article 5

Winter 2021

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ABSTRACT

This article offers a novel account of the likely impact of new technologies—such as big data, algorithms, artificial intelligence, the blockchain, and smart contracts—on corporate governance. It shows that, contrary to common predictions, one of the most significant and immediate effects of these technologies on corporations concerns the distribution of competences and responsibilities among corporate bodies. The claim is supported by identifying five primary determinants of the current balance of powers in corporate organizations: (i) the speed and frequency of the decisions; (ii) the information necessary to decide and who has access to it; (iii) the costs of assigning decision-making responsibilities to a collegial body; (iv) the decision-makers' incentives and interests; and (v) their competence and skills. Looking at whether and how these five dimensions are altered by technological innovation is the essential, and yet unexamined, analytical tool to accurately predict the impact of technology on corporate governance. While in some cases technological innovations may simply require managers to possess or acquire new competences and skills or may strengthen existing corporate roles, providing those who already make decisions with new tools to operate more efficiently, in other cases technology may shift the balance on who is the best decision-maker within the corporation. Technology may reduce some of the transaction costs that make collective decision-making burdensome for some corporate actors, suggesting, for example, that decisions that have been traditionally reserved for the board of directors may be made by shareholders. Similarly, competences that have commonly been delegated to executive officers and managers because of the need of particular operating expertise may shift back to the board of directors due to the informational decision-making support provided by technological tools. The result may not seem revolutionary at first glance, but it has potentially disruptive consequences for existing corporate governance models.

INTRODUCTION

The relationship between business and technology has historically been very close. Every major period of economic development in the United States and abroad has coincided with one or more technological innovations, each readily embraced by the business community. From ancient times to the present day, applying these new discoveries to business has made progress possible. The steam engine, electricity,[1] the telephone, the ATM machine,[2] and even the filing cabinet[3] and the high-rise office block,[4] which have immediate use in management, are famous examples of innovations that are commonly associated with periods of growth from the first industrial revolution to the economic boom and financialization of the twentieth century.

Even though technologically induced socioeconomic changes have often been profound, there is reason to believe that the technologies of the twenty-first century will be even more disruptive than those past. The speed at which change seems to occur is one reason.[5] Another is that big data,

* Bocconi University, Milan. I am indebted to Marco Cian and Claudia Sandei, who gave me the opportunity to present an earlier draft of this article, entitled *The (Un)Predictable Impact of Technology on the Distribution of Corporate Powers and Responsibilities*, at the international seminar "Corporate Strategy and Governance in the Digital Age" held on November 8, 2019, within the Ph.D. program in Legal Sciences of the University of Milan, and to the participants in the seminar for valuable inputs. I would also like to thank Luca Enriques, Mariateresa Maggiolino, Daniel Markovits, and Gabriele Nuzzo for helpful comments and conversations. All errors remain mine alone.

1. In a recent communication on the development and use of artificial intelligence in the European Union, the European Commission notably drew a parallel between the impact of the steam engine and electricity on past socio-industrial development and the possible effects of artificial intelligence on our society. *See Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. Artificial Intelligence for Europe*, at 1, COM(2018) 237 final (Apr. 25, 2018).

2. *See* Douglas W. Arner, Janos Barberis & Ross P. Buckley, *The Evolution of Fintech: A New Post-Crisis Paradigm?*, 47 GEO. J. INT'L L. 1271, 1274, 1279 (2016) (arguing that the invention of the ATM machine marks the beginning of modern Fintech).

3. *Cf.* Shelley Hayduk, *From Filing Cabinets to Digital Thought*, THE ATLANTIC (Mar. 15, 2011), https://www.theatlantic.com/technology/archive/2011/03/from-filing-cabinets-to-digital-thought/72490/.

4. *See generally* Gunter Gad & Deryck W. Holdsworth, *Corporate Capitalism and the Emergence of the High-Rise Office Building*, 8 URB. GEOGRAPHY 212 (1987) (examining the connection between the rise of corporate capitalism and the construction of high-rise office buildings in Toronto).

5. *See* Arner, Barberis & Buckley, *supra* note 2, *passim* (emphasizing the speed of technological development and evolution in the context of FinTech). Note, however, that GDP growth and total factor productivity in the United States do not seem to support the conclusion

artificial intelligence, algorithms, blockchains, and smart contracts have far-reaching consequences in many fields, including business strategy,[6] competition,[7] the labor market,[8] and even the democratic and political discourse.[9] The Cambridge Analytica scandal, involving the unauthorized harvesting of personal data of Facebook users,[10] showed how big data can be used to influence public opinion on political matters. Google and Amazon are modern-day champions of algorithmic profiling, providing personalized search results and purchase suggestions on the basis of previous online (and, thanks to the Internet of Things, even offline) customer behavior. Uber has made its fortune by being the first company in the transportation industry with no transportation means and, at least according to its management, no employees.[11] Even more traditional manufacturing companies, such as BMW, are now trying to integrate big data and artificial intelligence into their business models.[12]

From a corporate law perspective, a third and perhaps more compelling reason to consider twenty-first-century technologies disruptive is that they

that the speed of innovation is currently at a historical high, although it might increase in the future. *See* VIJAY KUMAR & R.P. SUNDARRAJ, GLOBAL INNOVATION AND ECONOMIC VALUE 84–88 (2018); MICHAEL GREENSTONE & ADAM LOONEY, A DOZEN ECONOMIC FACTS ABOUT INNOVATION 10 (2011), https://www.brookings.edu/wp-content/uploads/2016/06/08_innovation_greenstone_looney.pdf. *See also* Brishen Rogers, *The Law & Political Economy of Workplace Technological Change*, 55 HARV. CIV. RTS.-CIV. LIBERTIES L. REV. 531, 554–55 (2020) (observing that current productivity statistics do not suggest high rates of automation).

6. *See* Ajay Agrawal, Joshua Gans & Avi Goldfarb, *Artificial Intelligence in the Boardroom*, 39 CORP. BOARD 16, 17–18 (2018).

7. *See, e.g.*, MARIATERESA MAGGIOLINO, I BIG DATA E IL DIRITTO ANTITRUST (2018).

8. *See, e.g.*, Cynthia Estlund, *What Should We Do After Work? Automation and Employment Law*, 128 YALE L.J. 254, 257–58, 263–301 (2018); Rogers, *supra* note 5, at 553–73.

9. *See* LAWRENCE LESSIG, THEY DON'T REPRESENT US: RECLAIMING OUR DEMOCRACY 67–136 (2019).

10. *See* Issie Lapowski, *How Cambridge Analytica Sparked the Great Privacy Awakening*, WIRED (Mar. 17, 2019, 7:00 AM), https://www.wired.com/story/cambridge-analytica-facebook-privacy-awakening/; Nicholas Confessore, *Cambridge Analytica and Facebook: The Scandal and the Fallout So Far*, N.Y. TIMES (Apr. 4, 2018), https://www.nytimes.com/2018/04/04/us/politics/cambridge-analytica-scandal-fallout.html. In the legal scholarship, *see*, *e.g.*, Paul Przemysław Polański, *Some thoughts on data portability in the aftermath of the Cambridge Analytica scandal*, 7 J. EUR. CONSUMER & MKT. L. 141 (2018); Chris Jay Hoofnagle, *Designing for Consent*, 7 J. EUR. CONSUMER & MKT. L. 162, 163 (2018).

11. On Uber's fissured workplace environment, *see, e.g.*, Estlund, *supra* note 8, at 257, 284–85; Rogers, *supra* note 5, at 571.

12. Bernard Marr, *How BMW Uses Artificial Intelligence And Big Data To Design And Build Cars Of Tomorrow*, FORBES (Aug. 1, 2017, 12:28 AM), https://www.forbes.com/sites/bernardmarr/2017/08/01/how-bmw-uses-artificial-intelligence-and-big-data-to-design-and-build-cars-of-tomorrow/#5520d0eb2b91.

seem to support the long-awaited modernization of corporate organizations and to profoundly change firms' inner workings. Over time, corporations have remained almost intact in their distinguishing features,[13] which entail a body of investor-owners delegating management to one or more people sitting on a board.[14] While mutual funds and other institutional investors helped introduce some changes in corporate governance, agency problems remain a well-known consequence of delegated management[15] despite technological advances.[16] Even the Internet—which made distance irrelevant, communications easy, and information widely accessible—did not bring about serious transformation. Even today, virtual shareholder meetings remain a distant possibility in many jurisdictions,[17] while proxy and direct voting continue to present practical challenges, including ensuring proper shareholder identification and vote recording.[18] Significantly, information readily available on the Internet has not even fully substituted paper documents and regular mail in corporate communications yet.[19] According to many commentators, this might soon change. Blockchain could revolutionize the way securities transactions are cleared and registered, ensuring specific shareholder identification as well as more transparency for corporate records and even virtual shareholder meetings.[20] Artificial

13. *See generally* John Armour et al., *What Is Corporate Law?*, *in* REINIER KRAAKMAN ET AL., THE ANATOMY OF CORPORATE LAW: A COMPARATIVE AND FUNCTIONAL APPROACH 1–15 (3d ed. 2017) (identifying the common legal features of corporations across different jurisdictions).

14. *Id.* at 11–13.

15. Michael J. Jensen & William H. Meckling, *Theory of the Firm: Managerial Behavior, Agency Costs, and Ownership Structure*, 3 J. FIN. ECON. 305, 308–10 (1976).

16. *Cf.* Luca Enriques & Dirk A. Zetzsche, *Corporate Technologies and the Tech Nirvana Fallacy*, HASTINGS L.J. (forthcoming) (manuscript available as European Corporate Governance Institute (ECGI) Law Working Paper No. 457/2019, 2020), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3392321 (questioning, at 4, 7, whether algorithms and machines can improve monitoring on corporate agents). *Cf. also* Sergio Alberto Gramitto Ricci, *Artificial Agents in Corporate Boardrooms*, 105 CORNELL L. REV. 869, 877, 906 (2020).

17. *See* Christoph Van der Elst & Anne Lafarre, *Blockchain and the 21st Century Annual General Meeting*, 14 EUR. COMPANY L. 167, 174 (2017) (observing that most E.U. members states do not allow virtual shareholder meetings); Dirk Zetzsche, *Corporate Governance in Cyberspace—A Blueprint for Virtual Shareholder Meetings* 27–28 (Heinrich Heine University Düsseldorf, Center for Business and Corporate Law Research Paper Series (CBC-RPS) No. 0011, 2005), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=747347.

18. *See, e.g.*, Marcel Kahan & Edward B. Rock, *The Hanging Chads of Corporate Voting*, 96 GEO. L.J. 1227 (2008); Christoph Van der Elst & Anne Lafarre, *Blockchain and Smart Contracting for the Shareholder Community*, 20 EUR. BUS. ORG. L. REV. 111 (2019).

19. *Cf.* Zetzsche, *supra* note 17, at 16–21.

20. *See infra* Part I.D.

intelligence could transform the way directors and officers make decisions in many different ways, from providing informational support to actually substituting them in whole or in part.[21] More generally, common predictions for technology's impact on corporations vary from forecasts of completely autonomous organizations, run entirely by algorithms,[22] to more limited improvements and efficiencies in the workings of corporate bodies and procedures. But why should the new technologies bring about more dramatic changes than the technologies of the past? How realistic are these predictions? And what transformations can we actually expect in corporate governance?

This article addresses these questions. It argues that, while the answer depends at least to some extent on the chosen time frame and on the specific technology considered, one of the most significant and immediate effects of the new technologies on corporations will concern the distribution of powers and responsibilities among corporate bodies.[23]

The current distribution of powers is well known and fairly similar across jurisdictions. Shareholders vote on control-related and structural decisions, such as appointing and removing the company's directors and approving mergers and liquidations. Directors, in turn, are responsible for making business decisions, such as whether to launch a new product or dismiss a supplier, but typically delegate day-to-day management to company executives and officers and retain policy-making and monitoring functions.

Unlike past technological innovations, twenty-first century technologies have the potential to alter this balance. Particularly if used in conjunction with one another, they may decisively affect the determinants along which corporate law traditionally assigns power to various corporate constituencies.

The article identifies five primary determinants of the current balance of powers in corporate organizations that concern which decisions must be made and how they should be settled. These determinants are (*i*) the speed and frequency of the decisions; (*ii*) the information necessary to decide (and who has access to it); (*iii*) the costs of assigning decision-making responsibilities to a collegial body; (*iv*) the decision-makers' incentives and

21. *See, e.g.*, Florian Möslein, *Robots in the boardroom: artificial intelligence and corporate law*, *in* RESEARCH HANDBOOK ON THE LAW OF ARTIFICIAL INTELLIGENCE 649, 657–66 (Woodrow Barfield & Ugo Pagallo eds., 2019).

22. *See infra* Part I.E.

23. *See* David Yermack, *Corporate Governance and Blockchains*, 21 REV. FIN. 7, 9 (2017) (observing that the changes made possible by blockchains "could dramatically affect the balance of power between directors, managers and shareholders.").

interests; and (*v*) their competence and skills. Looking at whether and how these five dimensions are altered by technological innovation is the essential, and yet unexamined, analytical tool to reliably and accurately predict the impact of technology on corporate governance. The main contribution of this article is, thus, to use these five factors to explain why and to what extent twenty-first century technologies may disrupt corporate organizations and governance.

New technologies may, for instance, significantly reduce the transaction costs that make collective decision-making burdensome for some corporate actors, such as the shareholders, suggesting that decisions that have traditionally been reserved for the board of directors may instead be made by the shareholder meeting, in whole or in part. Similarly, responsibilities that have commonly been delegated to executive officers and managers because of their particular operating expertise may shift back to the board of directors due to the informational decision-making support provided by technological tools. Modern technologies may even change the ratio of company executives to non-executive employees, allowing the first to control and manage a higher number of production workers with fewer—or possibly without any—middle managers, leading to significant changes in corporations' organizational charts. More fundamentally, new technologies may strengthen existing corporate roles, providing those who already make decisions with new tools to operate more efficiently or, conversely, shift the balance on who is, in certain respects, the best decision-maker within the corporation. The result may not seem revolutionary at first glance, but it foreshadows potentially disruptive consequences for existing corporate governance models and demands renewed attention to ad hoc contractual solutions aimed at redesigning the roles of shareholders, directors, and managers on a case-by-case basis.

Examining how technology alters the five dimensions listed above also enables us to appreciate the limits and constraints of technologically induced organizational change. For example, modern technologies do not provide competence and skills to those who do not have them; this remains a powerful theoretical limit to the scope of any conceivable reshuffle of corporate roles and functions.

In this respect, the article builds on and implicitly supports one of the most basic claims of principal-cost theory[24]—namely, that competence considerations and costs play a fundamental role in determining a firm's optimal governance structure. Principal-cost theory teaches that optimal

24. *See* Zohar Goshen & Richard Squire, *Principal Costs: A New Theory for Corporate Law and Governance*, 117 COLUM. L. REV. 767 (2017).

governance requires minimizing both principal and agent costs, which are the economic losses that either the principal or the agent produce when exercising control. These significantly include, among others, the cost of honest mistakes made by the principal due to lack of competence, expertise, information, or talent (the so-called "principal competence costs"); this is the main reason that most enterprises delegate tasks to management in the first place.[25] Unless the principal has the necessary competence to run the business, it is "cheaper" to devolve it to management than to retain it.[26]

Technology enthusiasts often claim that technological innovations such as blockchains and smart contracts will enable shareholders to assume direct control of the firm and will downsize or eliminate the need for directors and managers altogether. This article shows, however, that technology does very little, if anything, to reduce principal competence costs; this is why we should not expect radical changes in the current distribution of powers and responsibilities among corporate bodies, at least in the short term and with respect to most firms. While technology might strengthen the decision-making and monitoring role of the shareholders vis-à-vis corporate directors and managers, competence acts as a fundamental limit to the extent to which shareholder empowerment in these two areas can take place. The article also demonstrates that competence and skill will continue to significantly characterize the role of corporate directors and managers even in the new technological era. Technology opens up opportunities and creates risks. Directors and managers will need to acquire new skills in order to exploit the former and understand and mitigate the latter. The creation of ad hoc internal tech departments and committees in charge of identifying and managing the unfolding possibilities and challenges of technological innovation will most likely follow suit. The overall result might be a stronger strategic and business role for corporate directors—that is, greater empowerment for those corporate constituencies who have, or could more easily acquire, the necessary competence to manage the business.

As a final methodological note, in discussing the impact of technology on the five factors listed above, the article focuses on the relationship between shareholders, directors, and managers and does not address whether directors and managers should in their business choices also account for the interests of a broader spectrum of corporate stakeholders.[27] The adoption of

25. The other reason is to reduce principal conflicts costs. *See id.* at 791–93, 802.

26. *Id.* at 770 (observing that "[t]o avoid such costs, [shareholders] delegate control to managers whom they expect will run the firm more competently").

27. The origins of the discussion can be traced back to the beginning of the 1930s. *Compare* Adolf A. Berle, Jr., *Corporate Powers as Powers in Trust*, 44 HARV. L. REV. 1049 (1931) (arguing that corporate managers should put the interests of shareholders first), *with*

a stakeholder theory of corporate governance or of other approaches namely, the team production theory of corporate law and the director primacy view[28] could in fact implicitly set a constraint on the shift in power that could or should be achieved through technological innovation, favoring in any case greater managerial discretion.[29] It remains true, however, that technology may also help empower (or disempower) different stakeholders, including customers, employees, suppliers, and local communities, in their interactions with the company.[30]

E. Merrick Dodd, Jr., *For Whom Are Corporate Managers Trustees?*, 45 HARV. L. REV. 1145 (1932) (contending that corporate managers should also consider the interests of other stakeholders). The dominant view has generally supported the shareholder primacy norm. Henry Hansmann & Reinier Kraakman, *The End of History for Corporate Law*, 89 GEO. L.J. 439, 440–42 (2001). New interest in this debate resulted, however, from the increasing attention paid by institutional investors to environmental, social, and governance (ESG) issues and from a recent statement of the Business Roundtable which, contrary to previous policy positions, supported a broader conception of the corporate purpose that considers the needs of all stakeholders. Business Roundtable, *Statement on the Purpose of a Corporation* (Aug. 19, 2019) https://opportunity.businessroundtable.org/wp-content/uploads/2020/03/BRT-Statement-on-the-Purpose-of-a-Corporation-with-Signatures.pdf. On the reasons for such a change of heart by the Business Roundtable, *see* Mark J. Roe, *Why Are America's CEOs Talking About Stakeholder Capitalism Now?*, OXFORD BUSINESS LAW BLOG (Nov. 7, 2019), https://www.law.ox.ac.uk/business-law-blog/blog/2019/11/why-are-americas-ceos-talking-about-stakeholder-capitalism-now.

28. For a recent account of these different corporate governance models, *see* Ronald J. Gilson, *From Corporate Law to Corporate Governance*, *in* THE OXFORD HANDBOOK OF CORPORATE LAW AND GOVERNANCE 3, 15–22 (Jeffrey N. Gordon & Wolf-Georg Ringe eds., 2018).

29. Unless one agrees with the claim that shareholders, and especially institutional investors, have an interest in environmental and social issues and should thus be the main advocates for stakeholder concerns. *Cf.* Marco Maugeri, «*Pluralismo» e «monismo» nello scopo della s.p.a. (glosse a margine del dialogo a più voci sullo Statement della Business Roundtable)*, 2019 ORIZZONTI DEL DIRITTO COMMERCIALE 637. *Cf. also* Chiara Mosca & Chiara Picciau, *Making Non-Financial Information Count: Accountability and Materiality in Sustainability Reporting*, *in* FINANCE DURABLE ET DROIT: PERSPECTIVES COMPARÉES 175, 181, 184–86 (Hugues Bouthinon-Dumas, Bénédicte François & Anne-Catherine Muller eds., 2020) (arguing that the European lawmaker has tried to make institutional investors more attentive to sustainability and ESG matters). From this perspective, shareholder empowerment could also serve to protect stakeholder concerns, and the reasoning of this article, which focuses on the relationship between shareholders and managers, would not be significantly affected.

30. Blockchains could, for instance, increase transparency toward different stakeholder groups, and smart contracts could help administer contractual relationships between some stakeholders and the firm. On blockchains and smart contracts, *see infra* Parts I.C and I.D. More generally, platform-style businesses already encourage collaboration among different stakeholder groups. *See* Mark Fenwick, Joseph A. McCahery & Erik P.M. Vermeulen, *The End of 'Corporate' Governance: Hello 'Platform' Governance*, 20 EUR. BUS. ORG. L. REV. 171, 172–73, 176, 193–94 (2019).

Against this background, the article proceeds as follows. Part I offers a brief overview of the technological tools and innovations that might affect twenty-first century corporations, such as big data, algorithms, artificial intelligence, blockchains, and smart contracts. Part II discusses the traditional distribution of powers and responsibilities among corporate bodies, identifying five criteria that help explain which corporate constituency—whether the shareholders, the board of directors, or the company executives—should make which decisions in the corporation's organizational structure and why. Arguably, factors such as the costs of collective decision-making or the decision-maker's incentives and skills help identify who should be in charge of a given decision, as well as the optimal allocation of responsibilities among corporate roles. Part III examines how new technologies may alter this balance—they have the potential to strengthen the deliberative role of the shareholder meeting by reducing the costs of collegial decision-making and enabling more efficient voting procedures. With the assistance of technological tools, the role of the board of directors might also change in fundamental respects, undertaking new responsibilities and benefiting from modern decision-making aids. Part IV develops three main policy recommendations that respond to the expected impact of technology on corporate roles and powers and argues that corporate law's enabling nature must be preserved and strengthened to facilitate innovation. Part V summarizes the results of the analysis and concludes the article.

I. TECHNOLOGY IN CORPORATE ORGANIZATIONS: FROM DIGITALIZATION TO AUTOMATION

Even after the Internet connected the world, bridging distances for people and businesses, corporate roles remained almost unchanged. Shareholder meetings have continued to occur once a year. Their task still is to elect the company's directors and to approve mergers, acquisitions, and other fundamental transactions (and, in certain jurisdictions, to vote on financial statements and the distribution of dividends). Even though the Internet made it easier to share information and communicate over long distances, shareholders of public corporations haven't begun to meet more frequently or become more involved in corporate affairs. Despite being technically feasible, virtual shareholder meetings are rare.[31] Electronic

31. Marie Clara Buellingen, *Virtual Shareholder Meetings in the U.S.*, HARV. L. SCH. F. CORP. GOVERNANCE (Oct. 10, 2019), https://corpgov.law.harvard.edu/2019/10/10/virtual-shareholder-meetings-in-the-u-s/ (noting that "physical shareholder meetings remain, by far, the most common approach for U.S. companies").

voting, either by proxy or directly, is common, but it usually continues to be connected with a physical assembly[32] whose attendance rates remain low. What changed the most is probably the way corporations disseminate information to the market, both in preparation for the annual general meeting and during the financial year. Information is now readily available on company websites and on publicly accessible databases (such as EDGAR),[33] with the consequence that, at least for public corporations, shareholders have easy access to all relevant documents. Digital means have, however, not entirely substituted paper-based correspondence, and lawmakers have not truly encouraged the precise replication of shareholder meetings on virtual platforms,[34] with some recent noteworthy exceptions due to the COVID-19 pandemic.[35]

The same is true with respect to the role of directors and managers. While internal communications and auditing systems have increasingly gone digital, core supervisory and managerial functions have been preserved. The board of directors maintains a monitoring and policy-making role vis-à-vis company executives, who are instead in charge of managing the day-to-day business. Although remote participation in board meetings has entered the routine, these gatherings continue to be held physically in many cases. Importantly, face-to-face meetings and phone conversations are still a very frequent form of private engagement between the company and its institutional investors or control shareholders, despite the increased availability of digital tools.[36]

32. With respect to Europe, see Van der Elst & Lafarre, *supra* note 18, at 121–23.

33. *About EDGAR*, SEC, https://www.sec.gov/edgar/aboutedgar.htm (last visited Apr. 5, 2020).

34. *See* Zetsche, *supra* note 17, at 13–28, 61.

35. For example, New York State Governor Andrew Cuomo recently issued an executive order temporarily suspending subsection (a) of Section 602 and subsections (a) and (b) of Section 605 of New York's Business Corporation Law, which require shareholder meetings to be held and noticed at a physical location, thus enabling New York companies to hold virtual shareholder meetings. N.Y. Exec. Order No. 202.8 (Mar. 20, 2020), https://www.governor.ny.gov/sites/governor.ny.gov/files/atoms/files/EO_202.8.pdf. In the international landscape, Italy provides another interesting illustration of the recent greater openness of lawmakers to virtual shareholder meetings. *See* Decreto Legge 17 marzo 2020, n. 18, G.U. Mar. 17, 2020, n. 70, art. 106.

36. *See, e.g.*, MARC GOLDSTEIN, DEFINING ENGAGEMENT: AN UPDATE ON THE EVOLVING RELATIONSHIP BETWEEN SHAREHOLDERS, DIRECTORS AND EXECUTIVES. A STUDY CONDUCTED BY INSTITUTIONAL SHAREHOLDER SERVICES FOR THE INVESTOR RESPONSIBILITY RESEARCH CENTER INSTITUTE 13–15 (2014), https://www.weinberg.udel.edu/IIRCiResearchDocuments/2015/09/engagement-between-corporations-and-investors-at-all-time-high1.pdf; Matteo Tonello & Matteo Gatti, *Board-Shareholder Engagement Practices. Findings from a Survey of SEC-Registered Companies* 14–15 (Dec. 2019), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3503657; Van der Elst & Lafarre, *supra* note 18, at 124–25.

The impact of twentieth century technologies on corporations has thus involved a substantial, but not yet fully developed, digitalization of procedures and communications, which did not affect the role and responsibilities of the corporation's constituent bodies. Shareholders, directors, and managers continue to do what they have always done, with the help of faster connections and more accessible information.

The reason for this, even intuitively, is that twentieth-century technologies simply provided more efficient ways of doing the same things, without reducing directors' dependence on managerial input and information or enabling effective shareholder empowerment. For example, they have not eliminated information asymmetries. Corporate management retained the power to decide what to disclose, to whom and when, although it could do so through faster and more efficient communication means. Similarly, twentieth-century technologies facilitated virtual shareholder meetings and greater shareholder participation, but they have not quite ensured tamper-proof voting procedures, and have only marginally reduced collective decision-making costs. Shareholder identification, coordination, and voting remain troublesome, and information gathering and processing are still a costly endeavor for many investors.

This article argues that the same is not true for certain recent technological innovations, which, despite being often analyzed and examined separately,[37] build on one another in reshaping the role and functions of the corporation's governing bodies. Recent research has typically addressed either how big data, algorithms and artificial intelligence may affect managerial decisions or, alternately, how blockchains and smart contracts may be employed to make shareholder meetings more efficient. Clearly, since artificial intelligence and algorithms, frequently working on big data, are decision-making tools, their most immediate application concerns those corporate constituencies—directors, officers, and managers—who usually make decisions. Similarly, since blockchains are distributed ledgers upon which computer programs may execute transactions (so-called "smart contracts"),[38] their most immediate use concerns shareholder identification at corporate meetings, the recording of share transfers, and the administration of voting procedures. However, looking at the impact of each new technological tool in isolation risks missing the big

37. For a significant exception in the legal scholarship, see Enriques & Zetzsche, *supra* note 16.

38. *See infra* Part I.C.

picture, as these technologies interact with one another and compound each other,[39] potentially reshaping existing corporate roles and functions.

Before delving deeper into the factors that should be employed to determine who should be in charge of a given decision within the corporation and how new technologies might affect this delicate balance, this Part describes the main technological innovations of the last decades in order to shed light on the unique features that make them suitable for application in business organization and governance.

A. Big Data Analytics and the Platform Economy

The expression "big data" refers to large databases of (unsorted) data, collected through technological and digital means, that are generally deemed valuable because of the knowledge that can be extracted from them.[40] Big data vary in content, depending on how they were compiled, who controls the database, and why they were collected. They may, for example, include consumer browsing or shopping behavior on e-commerce websites acquired through Internet cookies, search histories, and other digital tools. They may comprise data on road traffic or driving habits, obtained through satellites, cameras, and car sensors. They may even encompass astronomical data, human genome data, or financial data.[41] Classifications based on the content of the collected information are thus not particularly instructive or useful. The common element is that the data are obtained, stored, and analyzed, often at significant speed, through technological means and that they enable their user to obtain valuable knowledge.

Interestingly, the knowledge that can be extracted from big data is not necessarily immediately obvious.[42] Take the classical example of an e-commerce website that records consumer searches and shopping choices. The data may reveal that a specific consumer prefers to read non-fiction or to wear silk blouses. It might also reveal other personal information that the consumer did not openly share, such as her age or income range, her political views, when she does most of her shopping (and presumably is not at work), and so on. Data analysis of online grocery shopping may allow one to infer,

39. *See* Mark Fenwick & Erik P.M. Vermeulen, *Technology and Corporate Governance. Blockchain, Crypto and Artificial Intelligence*, 48 TEX. J. BUS. L. 1, 3–4 (2019).

40. *See* MAGGIOLINO, *supra* note 7, at 21, 28–31. *See also* JULIE E. COHEN, BETWEEN TRUTH AND POWER. THE LEGAL CONSTRUCTIONS OF INFORMATIONAL CAPITALISM 48–74 (2019) (arguing that personal data are playing the role of raw materials in the information economy, constituting a new public domain: the "biopolitical public domain").

41. MAGGIOLINO, *supra* note 7, at 30.

42. *See id.*

from the goods the consumer buys or does not buy anymore, whether she lives alone, is pregnant, is on a diet, has a health condition, might soon suffer from one, is assisting an elderly parent, and so forth. This enables companies to target marketing campaigns, offer personalized shopping suggestions, and adjust search results on the basis of what they expect the consumer will want to purchase in the future. In other words, big data enable businesses to create rather accurate consumer profiles and to reasonably predict consumer behavior. These predictions are, in turn, valuable for two reasons. They can be directly employed to offer customized services that are likely to be successful or they can be sold to third parties, allowing them to extract different, equally valuable knowledge from the same dataset.[43]

Although big data are also gathered by public bodies, governmental agencies, and other entities for many different purposes, they are generally associated with Internet platforms such as Facebook or Amazon.[44] Platforms are in a unique position to collect and exploit large amounts of data because users interact with them in a variety of ways. The more frequent and diverse these interactions are, the more opportunities the platform has to collect data. Facebook, for instance, has access to users' personal information, "likes," comments, posts, search histories, and much more. Amazon, Google, Uber, and other platform providers work in much the same way. They connect individuals and businesses, mediating communications and exchanges.[45] In the process, they collect information on what these people say or do on the platform. As a result, although originally the term *platform* merely identified the technical base upon which computer programs ran,[46] today platforms are complex infrastructures, built around networks[47] that enable the collection and exploitation of what has been termed the "fourth factor of production": "the data flows extracted from people."[48]

43. *See id.* at 186–88 (describing data marketplaces). *See also* COHEN, *supra* note 40, at 68–70.

44. *See, e.g.*, Fenwick, McCahery & Vermeulen, *supra* note 30, at 174–78, 187–97 (describing platforms, their business models, and what governance models based on a platform structure could look like).

45. *See* Mireille Hildebrandt, *Primitives of Legal Protection in the Era of Data-Driven Platforms*, 2 GEO. L. TECH. REV. 252, 254–55 (2018) (drawing parallels between modern-day platforms, the Greek *agora*, and the Roman forum as spaces for market exchanges, political discourse, and other forms of expression).

46. Tarleton Gillespie, *The Politics of 'Platforms'*, 12 NEW MEDIA & SOC'Y 347, 351 (2010); also cited by Hildebrandt, *supra* note 45, at 254.

47. *Cf.* COHEN, *supra* note 40, at 40–42 (on the difference between platforms and networks).

48. *Id.* at 38, 41.

The close link between big data and platforms is at the foundation of the so-called "platform economy" or "informational economy."[49] The model is fairly simple. Most of what happens on the Internet happens through platforms: communications, finance, transactions in goods and services, entertainment, social contacts, even employment.[50] Platforms mediate and facilitate these relationships and interactions. In doing so, they have unique access to a pool of comprehensive and diverse data on each participant in the network that extends beyond the specific transaction or communication considered. In this respect, online environments and real-life situations have a major difference. A shopkeeper will, for example, focus on what customers like and buy, not so much on other details, such as at what time of the day a particular customer shops, how much time she spends in the shop, whether she is talking to someone while shopping, how often she shops, and so forth. In contrast, everything that we do on the Internet is tracked, recorded, and "surveilled,"[51] representing potentially valuable information. The more activities we undertake in an online environment, the more information the owner of the platform can collect on our behavior. This is a powerful function: a platform can observe our online behavior in its entirety, measure all its relevant aspects, and then analyze the data to obtain valuable knowledge.

The goal is to provide a stable point of mediation for the largest possible number of users, in order to have access to increasing amounts of analyzable data and eventually to substitute entire markets.[52] One way through which this happens is by exploiting the data themselves to make users and customers rely on the platform. Social networks, for instance, often "test" user reactions by providing triggers and rewards that aim to induce recurrent behaviors. Big data and artificial intelligence are employed to find out what users like. This in turn is exploited to make the online experience more addictive, in a complex trigger-and-reward system that may even be used to affect user behavior.[53] This mechanism has gained attention, especially in connection to its possible influence on elections and political discourse.[54] However, it also has important implications for the development of new

49. *See id. passim* (defining platforms as "the core organizational logic of the informational economy").

50. *See id.* at 37.

51. *See generally* SHOSHANA ZUBOFF, THE AGE OF SURVEILLANCE CAPITALISM: THE FIGHT FOR A HUMAN FUTURE AT THE NEW FRONTIER OF POWER (2018).

52. COHEN, *supra* note 40, at 42. *Cf.* Brishen Rogers, *The Social Costs of Uber*, 82 U. CHI. L. REV. DIALOGUE 85, 86–90 (2015) (describing Uber's market-making function).

53. *See, e.g.*, LESSIG, *supra* note 9, at 114–17, 122–23, 125, 192.

54. *See id.* at 119–22.

products, services, and markets more generally. Customer loyalty is, in fact, essentially obtained through network externalities and personalized services.

B. Algorithms, Artificial Intelligence, and Machine Learning

What spurred the rise of platforms and their business models? Widespread access to the Internet provides one piece of the puzzle, while improvements in hardware and software, which made it possible for computers to store and process large amounts of data, largely account for the remaining elements.[55] However, the fundamental factors undoubtedly were the development of proprietary algorithms[56] and artificial intelligence.[57] Platforms make considerable use of both in order to offer personalized services.

In very broad terms, artificial intelligence is the ability of computers and other machines to behave in a way that appears "smart" or "intelligent" to an external observer.[58] The technologies that enable this are different and many.[59] Famous examples are decision-making programs that employ (proprietary) algorithms and machine learning.[60]

Algorithms provide the technical tool to extract knowledge from a database. Although they are frequently used in connection with (large)

55. *See* Fenwick, McCahery & Vermeulen, *supra* note 30, at 187 (identifying improvements in hardware, connectivity, cloud-based storage systems for big data, and algorithms as the drivers of platform expansion). *See generally* ETHEM ALPAYDIN, MACHINE LEARNING: THE NEW AI 1–7 (2016) (discussing computers' increased ability to store and exchange data).

56. *Cf.* COHEN, *supra* note 40, at 45–46 (describing how platforms enable commercial counterparties, such as app developers and advertisers, to interact with potential customers without granting them access to the platform's databases and algorithms).

57. *See* John Armour & Horst Eindenmüller, *Self-Driving Corporations?*, 10 HARV. BUS. L. REV. 87, 92–95 (2020) (on the origins and present state of artificial intelligence).

58. *See id.* at 92 (pointing out that the understanding of artificial intelligence as a machine that appears smart and intelligent, using as a basis for comparison the human intellect, has its origins in the work of Alan M. Turing. A machine passes the so-called "Turing test" if an interrogator, questioning a human and the machine without knowing who is what, would not be able to determine whether she is talking to a machine or a human based on their answers) (quoting from Alan M. Turing, *Computing Machinery and Intelligence*, 59 MIND 433 (1950)).

59. *See* Möslein, *supra* note 21, at 655–56.

60. *See* Harry Surden, *Machine Learning and Law*, 89 WASH. L. REV. 87, 90 (2014) (noting that the results of machine learning algorithms may appear "intelligent"). *See generally* Bernard Marr, *What Is The Difference Between Artificial Intelligence and Machine Learning?*, FORBES (Dec. 6, 2016, 2:24 AM), https://www.forbes.com/sites/bernardmarr/2016/12/06/what-is-the-difference-between-artificial-intelligence-and-machine-learning (distinguishing artificial intelligence from machine learning).

datasets, algorithms are, in a strict sense, instructions that a computer uses to perform a task.[61] Software programmers may explicitly formulate those instructions—for example, through coding. In these instances, human programmers tell the software what to do and how to do it, by spelling out in programming languages what inputs to use and how to process them.

Machine learning represents a more sophisticated use of algorithms. In this case, the computer program is not given instructions on how to perform a task, but it is programmed to elaborate its own instructions by a complex trial-and-error procedure based on data.[62] The data might be, as is often the case, "big data," but this is not strictly necessary. Machine learning is in fact any learning activity autonomously performed by a computer program on a given set of data.[63] The most successful machine learning programs so far are supervised learning programs[64] that make use of deep learning techniques: a setup in which the data are analyzed in series through a process of abstraction and recalibration that should ideally resemble the thought process of the human brain.[65] These programs are trained on a labeled dataset put together by flesh-and-blood programmers. On the training dataset, the computer identifies hidden patterns, rules, and consistencies that it later uses to create new instructions to perform on a new and unknown dataset the same task that was successfully executed on the training data. For example, programmers may train computers to provide translation services.[66] In order to do so, they put together a training dataset that may include words and sentences in one language and their translations in another language. The programmers, however, do not give the program any grammar or syntax rule

61. ALPAYDIN, *supra* note 55, at 16.

62. *See, e.g.*, *id.* at 16–17, 24–26; David H. Autor, *Polanyi's Paradox and the Shape of Employment Growth*, *in* FEDERAL RESERVE BANK OF KANSAS CITY: ECONOMIC POLICY SYMPOSIUM PROCEEDINGS. REEVALUATING LABOR MARKET DYNAMICS 129, 158–62 (2015) (providing examples of how machine learning systems are programmed and work); Surden, *supra* note 60, at 90–95 (describing the main features of machine learning algorithms and providing an example of how they can automate spam email filtering).

63. *See generally* ALPAYDIN, *supra* note 55, at 17–54 (providing background information on what learning entails and how artificial intelligence makes use of statistics to "learn" and make predictions).

64. Armour & Eindenmüller, *supra* note 57, at 95 (also pointing out that supervised learning programs are different from unsupervised and reinforcement learning systems. Unsupervised learning does not make use of labeled training datasets, while reinforcement learning only works by providing the system with a reward for identifying the correct answer. These two techniques have had some success, but far more limited applications.).

65. *Id.* at 93–95. *See generally* ALPAYDIN, *supra* note 55, at 85–109 (explaining how artificial neural networks and deep learning work).

66. Surden, *supra* note 60, at 99–100 (describing how machine learning tools for translation services work).

that the software should follow in delivering the translation.[67] They simply evaluate the outcome. By telling the program whether the outcome of the translation was right or wrong, the program adjusts for future applications. In this sense, the machine autonomously "learns" which patterns and rules are hidden in the data and performs the task based on those consistencies. Curiously, while the rules that artificial intelligence programs might identify in a given dataset may not correspond to actual rules, the outcome is often still fairly correct.

In the case of a translation, understanding what hidden patterns and rules the machine found is not of utmost importance, provided that, at least intuitively or implicitly, we know how different languages work and simply wish a computer program to replicate, as close as possible, what any human translator already does well. The ability to find hidden patterns, rules, and consistencies becomes, however, very important when we do not know what they are and how they work, but simply know they exist.[68] It is precisely in this respect that machine learning, in conjunction with big data, offers the greatest innovation. Machine learning can be employed not only to replicate tasks that humans do well, but also to perform tasks that humans are not able to do accurately or at all because of their limited computing abilities or their insufficient understanding of the underlying processes and rules. A human observer may, for example, anticipate, based on experience, what another person would say or do in a certain situation but might not be able to accurately extend the prediction to other people or all situations. This is because there is a limit to the data and information that humans can acquire, store, and analyze at once. Moreover, while we have some knowledge of cognitive processes and biases, our understanding of human behavior is, in general, still flawed. This means that no programmer could teach a machine to read, interpret, and anticipate human behavior. It does not mean, however, that a machine could not learn to do this by itself, and the outcome won't

67. This approach was actually tried by encoding grammatical rules in computer programs tasked to recognize and translate language, but the programs failed. Machine learning algorithms have instead provided much better results. *Id. See generally* Armour & Eindenmüller, *supra* note 57, at 93 (observing that in the first stage of developing artificial intelligence, programmers attempted to feed programs with formal logic rules. This approach did not succeed due to the complexity of real-world problems and the difficulties in the deterministic calculation of all their possible outcomes).

68. *See* ALPAYDIN, *supra* note 55, at 14 (defining consumer "data mining" as a type of machine learning for which "[w]e do not know the rules (of customer behavior), so we cannot write the program, but the machine—that is, the computer—"learns" by extracting such rules from (customer transaction) data."); Surden, *supra* note 60, at 107 (observing that machine learning can be used to discover "hidden relationships in existing data that may otherwise be difficult to detect.").

necessarily be less accurate than when a real person performs such a calculation. Machines have greater storage and computing abilities, which enable them to "outsmart" their flesh-and-blood counterparts in situations where the underlying knowledge is murky, the data necessary to perform the task are vast, and speed of computing is key. By making use of these enhanced capabilities and working on large datasets, artificial intelligence improves our knowledge of the world, suggesting what hidden patterns and consistencies may hide behind an observed result.

Importantly, the algorithms autonomously elaborated by machine learning software on the basis of data need not be—and often are not—fully understandable or transparent to human programmers to be of valuable commercial use.[69] Only the result of the predictive or analytic activity must be. Thus, although machine learning is useful mostly in connection with tasks for which we know that there are hidden patterns or rules, it will not necessarily shed light on what these are and how they work. As a matter of fact, the rules that artificial intelligence programs identify in a given dataset not only may not correspond to actual rules, but they may never become fully distinguishable or comprehensible—yet artificial intelligence can still deliver accurate predictions.

An example may help clarify the concept. Suppose that a restaurant chain wishes to know which dishes and drinks its customers are likely to order more often than not so as to revise its menu.[70] The managers know that customer preferences change over time and depending on the location, but they do not know exactly what these preferences are. Indeed, while a single restaurant might be able to make rather accurate predictions, considering its limited customer base and particular location, a restaurant chain might encounter more difficulties. The task is, however, not hopeless, because "customer behavior is not completely random."[71] One might expect, for instance, that customers order more soup in the winter and more sorbets in the summer or that their drinking choices vary depending on the time of the year. There are, in other words,

> patterns in customer behavior, and this is where data comes in to play. Though we do not know the customer behavior patterns themselves, we expect to see them occurring in the collected data. If

69. *See* Rogers, *supra* note 5, at 558.

70. The example in the text adapts the example of the supermarket chain provided in ALPAYDIN, *supra* note 55, at 11–13.

71. *Id.* at 13.

> we can find such patterns … we can make predictions based on them.[72]

Better predictions enable, in turn, better business choices, increasing the profitability of those upholding them. Artificial intelligence helps precisely in making these predictions and, in some cases, directly makes decisions based upon them. It may show, for example, that customers in a particular location drink significantly more beer in the summer than in the winter or compared to other locations, although there is no apparent reason for this. The system may thus automatically change the menu in order to offer a wider or narrower choice of beer in different seasons or cities. Significantly, artificial intelligence users need not fully understand why customers in a specific location are particularly fond of beer to benefit from this indication. (Is it simply habit, a trend, loyalty to a locally handcrafted beer, or does beer just match well with the menu according to the prevalent taste of the people living in a specific area?). They can just adjust the menu.

As the example suggests, machine learning applications, especially when based on big data, can produce knowledge that we do not already have and that might be of valuable commercial use. After all, any menu that accurately targets consumer preferences will fill restaurants and bars. This intuition is precisely what fueled the growth and expansion of online platforms such as Amazon and Google, which profit from accurately predicting consumer preferences and choices. Despite being an oversimplification of how big data, artificial intelligence, and machine learning work, the analysis above underscores a fundamental aspect of these new technologies. Their main output is a predictive activity that provides a valuable decision-making aid and that, in some instances, may even fully substitute human decision-makers.[73]

C. Blockchain Technology and Smart Contracts

Blockchains are distributed ledgers that record information in a manner that is sequential, unmodifiable, shared, and synchronized among participants.[74] The original idea of a sequential reporting system was put forward in 1991 in order to ensure the certainty of intellectual property

72. *Id*.

73. Möslein, *supra* note 21, at 656.

74. *See, e.g.*, PRIMAVERA DE FILIPPI & AARON WRIGHT, BLOCKCHAIN AND THE LAW 13–57 (2018) (explaining the technology behind blockchains); Sinclair Davidson, Primavera De Filippi & Jason Potts, *Blockchains and the economic institutions of capitalism*, 14 J. INSTITUTIONAL ECON. 639 (2018) (arguing that blockchains are an institutional innovation).

rights. Intellectual property rights were supposed to be time-stamped at their creation and then chained together through hash functions, a method of cryptography used to convert numbers of any length into fixed-length numbers.[75] These given-length numbers, obtained solving a mathematical problem, are employed to univocally identify the underlying data in an easily verifiable way.

The idea was later developed in order to create and manage the world-famous virtual currency "Bitcoin."[76] Bitcoin transactions are, in fact, administered on a public blockchain. Participants are able to add blocks of transaction data, verify their integrity through a chain of hash functions, and then store a copy of the recordings. The term "blockchain" suggests that the transactions are bundled together in "blocks" and then chained with one another through cryptography. In the Bitcoin blockchain, so-called "miners" compete with each other to bundle transaction data and create new blocks. Each block is identified by a unique hash function and reflects "the contents of the previous block, which itself includes a hash function derived from its predecessor, and so forth, all the way back to the first block in the chain."[77] More specifically, each new block contains transaction data, the previous hash, a time-stamp, and other data, the "nonce": a random number, usually different for every miner, that enables the creation of a new hash.[78] The fastest miner to come up with a valid hash function is rewarded with Bitcoins for having completed a block that other participants later verify and add to their copy of the blockchain.[79] If any participant in the blockchain were to alter a block after it is formed and chained to others, its unique hash function would change in a readily identifiable manner and, as a consequence, all the hash functions associated with the subsequent blocks would be altered.[80] This ensures the integrity and certainty of the recordings for all participants in the blockchain.

75. Yermack, *supra* note 23, at 10–11.

76. The Bitcoin blockchain was developed from the idea of Satoshi Nakamoto (a developer whose real identity is still unknown), laid out in a famous white paper available online. *See* Satoshi Nakamoto, *Bitcoin: A Peer-to-Peer Electronic Cash System* (2008), https://bitcoin.org/bitcoin.pdf.

77. Yermack, *supra* note 23, at 11–12.

78. *Id.* at 13, 13 n.10.

79. *See* Daniel Ferreira, Jin Li & Radoslawa Nikolowa, *Corporate Capture of Blockchain Governance* (European Corporate Governance Institute (ECGI) Finance Working Paper No. 593/2019), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3320437 (discussing the "proof-of-work" system, which enables decentralized record verification and governance on blockchains, as well as the risk of blockchain capture by the dominant mining equipment producer).

80. *See, e.g.*, DE FILIPPI & WRIGHT, *supra* note 74, at 25; Yermack, *supra* note 23, at 14.

A key component of the original blockchain idea was that the sequence of the recordings should be accessible to the public in order to prevent alterations and manipulations. In 1991, this could have been done by publishing the records in a newspaper or on another similar public source.[81] In the Bitcoin blockchain, it is ensured by opening the network to all interested parties, so that each party stores a copy of the blockchain on its hardware, and by employing a distributed and consensus-based mechanism to establish what is authentic.[82] Indeed, one would have to control over half of the nodes in the network to tamper with existing records or to make fake ones; this is generally thought impossible due to the exceptionally high investment and computing power that it would require, at least for popular blockchains such as Bitcoin.[83]

Blockchains may also be private or "permissioned." This means that they are restricted to selected members and, in case of permissioned blockchains, they may be managed by a sponsor according to an agreement among the parties.[84] The sponsor administers the network, has the power to admit new participants pursuant to the agreement, and verifies the transactions recorded on the distributed ledger. Permissioned blockchains offer some of the most promising uses of this technology for firms.[85] Corporations could, in fact, establish their own blockchain in order to register share ownership or for corporate accounting and reporting purposes.

An additional feature of blockchain technology is that participants in the network can run smart contracts on it. Although there are many definitions of the term,[86] a smart contract is essentially "a computerized transaction protocol that executes the term of a contract":[87] a set of

81. *See* Yermack, *supra* note 23, at 11.

82. *See* DE FILIPPI & WRIGHT, *supra* note 74, at 23–24, 35–38. *See also* Enriques & Zetzsche, *supra* note 16, at 9–10 (explaining the difference between distributed ledgers and concentrated ledgers with respect to the risk of manipulation or corruption).

83. DE FILIPPI & WRIGHT, *supra* note 74, at 25, 113–14.

84. *See, e.g.*, *id.* at 31–32; Yermack, *supra* note 23, at 12, 16; Jun Dai & Miklos A. Vasarhelyi, *Toward Blockchain-Based Accounting and Assurance*, 31 J. INFO. SYS. 5, 6–7 (2017) (distinguishing between private and permissioned blockchains).

85. *Cf.* Van der Elst & Lafarre, *supra* note 18, at 127–29 (providing examples of how permissioned blockchains could be used for shareholder meetings and for the exercise of shareholder rights).

86. Riccardo de Caria, *The Legal Meaning of Smart Contracts*, 26 EUR. REV. OF PRIV. L. 731, 734–35 (2019).

87. Nick Szabo, *Smart Contracts*, U. AMSTERDAM (1994), http://www.fon.hum.uva.nl/rob/Courses/InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/smart.contracts.html. *See also* Nick Szabo, *Formalizing and Securing Relationships on Public Networks*, FIRST MONDAY (1997), https://journals.uic.edu/ojs/

instructions that is automatically implemented when given conditions are verified. The terms of the agreement between the parties are written in code language, which a computer program automatically enforces.

Imagine that two parties use a smart contract to execute a future on shares,[88] agreeing that on a certain date, party A will transfer the ownership of 100 shares of Company X to party B, at a fixed price of $1,000. These instructions are embedded in a computer protocol ("coded") in order to avoid intermediaries, enforcement costs, contract breaches, and other impediments. When the date arrives, the computer program will execute the instructions, transferring the shares from A to B and the money from B to A, without the need for any further action on their part or the intervention of any intermediary or enforcer. When smart contracts run on a blockchain, the parties exploit its network structure to make the transaction immutable and verifiable. In this case, each party uses its blockchain account to receive and make the transfers, which are then executed by a computer program directly on the network. The advantage, especially for public blockchains, is that the terms of the contract and its enforcement are distributed among many parties, which jointly record them, ensuring transaction certainty and immutability.[89]

D. From the Digitalization of Corporate Reporting and Procedures …

Blockchains and smart contracts, in their simplest version of coding instructions (such as "if A, then B"),[90] may lead to a variety of corporate innovations, ranging from the digitalization of company reporting and procedures to more structural developments in the role and functioning of corporate bodies, especially the shareholder meeting.

With respect to the first set of changes, blockchains and smart contracts could be employed to organize the internal accounting system of corporations and to automate corporate reporting.[91] Business transactions with third parties could be recorded in real-time through private, permissioned or even public blockchains, which would ensure certainty and integrity of the recorded data, as well as access to, and verification by, all

index.php/fm/article/view/548/469. For further discussion on smart contracts, *see, e.g.*, Kevin Werbach & Nicolas Cornell, *Contracts Ex Machina*, 67 DUKE L.J. 313 (2017).

88. *See generally* DE FILIPPI & WRIGHT, *supra* note 74, at 93–96 (discussing smart securities and derivatives).

89. *See* Dai & Vasarhelyi, *supra* note 84, at 7.

90. *Cf.* DE FILIPPI & WRIGHT, *supra* note 74, at 29.

91. *See, e.g.*, Dai & Vasarhelyi, *supra* note 84, *passim*; Yermack, *supra* note 23, at 24–26; Fiammetta S. Piazza, *Bitcoin and the Blockchain as Possible Corporate Governance Tools: Strengths and Weaknesses*, 5 PENN ST. J. L. & INT'L AFF. 262, 295–96 (2017).

(authorized) participants. Blockchain technology could improve tracking of internal accounting information, entrusting managers, auditors, and other chosen parties to validate recordings. Significantly, disclosure of accounting documents could be provided on a selective basis, grouping identified recipients in "aggregation levels" that would obtain access to predetermined parts of the blockchain depending on their role.[92] Computer programs could then build accounting reports and financial statements based on the blockchain recordings in a traceable and verifiable manner. This system greatly reduces the risk of accounting manipulation, documentation error, and fraud[93] by adopting a triple-entry accounting mechanism: Transactions are recorded by the two parties involved and by an independent intermediary, represented by (all the nodes in) the blockchain.[94] The additional advantage compared to ordinary triple-entry accounting systems is that the blockchain effectively prevents tampering by third parties, including cyberattacks, given that the recorded transactions can hardly be modified or altered at a later date.[95]

Blockchain-based accounting could also facilitate external auditing by specialized firms, as well as supervision by the competent governmental authorities, which could easily have or obtain access to the distributed ledger.[96] Smart contracts could, for example, enable auditors to establish targeted controls on the recorded transactions. Business rules and accounting standards could likewise be encoded as smart contracts in a blockchain, facilitating internal monitoring and external auditing services, thus preventing possible violations from the outset.[97]

92. Dai & Vasarhelyi, *supra* note 84, at 6, 13. For more general observations on the possibility of granting selective access to the contents of a blockchain to certain authorized participants, see Carla L. Reyes, Nizan Geslevich Packin & Benjamin P. Edwards, *Distributed Governance*, 59 WM. & MARY L. REV. ONLINE 1, 24 (2017).

93. *But see* Piazza, *supra* note 91, at 296 (arguing that companies could still circumvent reporting duties by maintaining a parallel system of accounting).

94. *See* Dai & Vasarhelyi, *supra* note 84, at 10–12 (discussing blockchain accounting).

95. *Id.* at 10.

96. *Cf. id.* at 13 (suggesting that smart contracts could be used to automate tax filings and provide continuous updates to the competent agencies).

97. Smart contracts could be used, for example, to confirm the balance sheet equation. In this case, "if the balance in the company account is set as the balance in the assets account less the total balance of the liabilities and equities account, then a smart contract could be created to monitor the balance of the company account, which issues alerts when the balance does not equal to zero." *Id.* at 12 (also showing, at 12–16, how blockchains and smart contracts could help verify corporate recordings, enable automatic assurance systems, and modernize audits). *See also* DELOITTE, BLOCKCHAIN TECHNOLOGY. A GAME-CHANGER IN ACCOUNTING? 3–4 (2016), https://www2.deloitte.com/content/dam/Deloitte/de/Documents/Innovation/Blockchain_A%20game-changer%20in%20accounting.pdf.

Among other promising uses of blockchain technology is its application to shareholder meetings.[98] According to many commentators, blockchains could successfully administer virtual shareholder meetings by tracing share transfers and identifying who is entitled to participate in the meeting and vote;[99] registering proxies, voting instructions, and actual votes;[100] ensuring that quorums and majority requirements are met;[101] shedding light on empty voting practices;[102] automatically preparing minutes of the meeting;[103] and so forth. Essentially, each voter would be uniquely identified by her blockchain account and would have voting tokens that she could then allocate to express her preference for a specific ballot.[104] This would readily

98. *See, e.g.*, Van der Elst & Lafarre, *supra* note 17, at 172–76; Van der Elst & Lafarre, *supra* note 18, at 125–31; CSD WORKING GROUP ON DLT IN COLLABORATION WITH SWIFT, GENERAL MEETING PROXY VOTING ON DISTRIBUTED LEDGER (2017), https://www.issanet.org/e/pdf/2017-11_General_Meeting_Proxy_Voting_on_Distributed_Ledger_v2-1.pdf.

99. *See, e.g.*, George S. Geis, *Traceable Shares and Corporate Law*, 113 NW. U. L. REV. 227, 254–70 (2018); Van der Elst & Lafarre, *supra* note 17, at 172–74; Fenwick & Vermeulen, *supra* note 39, at 8. Significantly, transfers of assets, including shares, have already been recorded on the Bitcoin blockchain through a method known as "colored coins." Essentially, for each transfer the seller sends the buyer a trivial amount of Bitcoin together with a "token," a piece of data identifying the asset that is actually being transferred. As the blockchain registers the transaction, it also registers the asset transfer. *See also* DE FILIPPI & WRIGHT, *supra* note 74, at 29–30; Yermack, *supra* note 23, at 16. More recently, several firms have been experimenting with blockchain-based securities clearance systems. For example, in August 2019, Securitize, a provider of blockchain-based platforms for token issuance, announced that it had been registered by the SEC as a transfer agent. This means that it can serve as the official keeper of records for the transfer of securities. *See* Press Release, *Securitize becomes an SEC-registered transfer agent to modernize capital markets through blockchain*, SECURITIZE (Aug. 21, 2019), https://staging.website.securitize.io/press/securitize-becomes-an-sec-registered-transfer-agent-to-modernize-capital-markets-through-blockchain.

100. *See, e.g.*, Yermack, *supra* note 23, at 23–24. For example, Broadridge Financial Solutions, Inc., a corporate services company, and ICJ, Inc., a joint venture of Broadridge and the Tokyo Stock Exchange, have developed and executed in a test environment a blockchain proxy-voting system designed specifically for the Japanese market; it mirrors traditional proxy voting but automates and simplifies it. *See* Press Release. *ICJ and Broadridge Execute the First Blockchain-based Interoperable Proxy Voting Process in Japan*, BROADRIDGE (Jan. 14, 2019), https://www.broadridge.com/intl/press-release/2019/icj-and-broadridge-execute-the-proxy-voting-process.

101. For example, through smart contracts running on blockchain. *See* BROADRIDGE, NEXT GENERATION PROXY VOTING. HOW DATA-DRIVEN ANALYTICS, OMNI-CHANNEL DELIVERY AND BLOCKCHAIN ARE HELPING MUTUAL FUNDS ACHIEVE THEIR PROXY GOALS 11 (2018), https://www.broadridge.com/_assets/pdf/broadridge-next-generation-proxy-voting-strategies.pdf.

102. *See, e.g.*, Yermack, *supra* note 23, at 24; Geis, *supra* note 99, at 269.

103. For an example with respect to board meetings' minutes, see Enriques & Zetzsche, *supra* note 16, at 11.

104. *See, e.g.*, Yermack, *supra* note 23, at 23.

enable distant voting and ensure certainty in voter identification and vote counts.

Clearly, blockchain technology is particularly suited to the most important function attributed to shareholder meetings: voting expression. Physical meetings, however, also perform other functions, including disseminating information and establishing a forum for participant discussion.[105] Critics of virtual shareholder meetings have long claimed that only physical gatherings can effectively serve all of these purposes at once.[106] This observation, however, does not apply, at least with the same strength, to blockchain-based shareholder meetings. Blockchains themselves may provide technical support in spreading information and enabling discussion, and they could even be supplemented by other devices, as simple as private platforms for communication, aimed at fostering dialogue among shareholders.[107] The advantages of greater certainty in the administration of voting procedures must, in any case, be balanced with the shortcomings of current voting systems, which often do not even identify sure winners,[108] and with shareholder absenteeism and rational apathy, which, especially in public corporations, suggest that the benefits of physical meetings might not be that important after all.[109]

E. … to Autonomous Algorithmic Entities

While blockchains and smart contracts promise to facilitate, digitalize, and improve corporate accounting and shareholder meetings, algorithms could help corporations make the transition to what has been called

105. *See, e.g.*, Zetzsche, *supra* note 17, at 7–8, 13–14 (observing that shareholder meetings might also trigger a review of management's activities). *But see* Van der Elst & Lafarre, *supra* note 17, at 167–71 (arguing that securities regulation and investor demands for information undermine the information function of the general meeting and that even the forum and decision-making functions are flawed in many respects); Van der Elst & Lafarre, *supra* note 18, at 122 (reporting that shareholders are not using the annual general meeting as a forum for discussion, since they mostly vote through distance voting mechanisms).

106. *Cf.* Ralph Simmonds, *Why must we meet? Thinking about why shareholders meetings are required*, 19 COMPANY & SEC. L.J. 506 (2001); Elizabeth Boros, *Virtual Shareholder Meetings*, 3 DUKE L. & TECH. REV. 1 (2004).

107. *See* Van der Elst & Lafarre, *supra* note 17, at 175 (on the use of blockchain-based platforms as a digital forum for discussion); Van der Elst & Lafarre, *supra* note 18, at 128 (also on blockchains as a discussion and communication tool). *See also* Zetsche, *supra* note 17, at 56–58 (proposing the use of "shareholder conferences" and chat boards for communications).

108. *See* Kahan & Rock, *supra* note 18, at 1248–70, 1279.

109. *Cf.* Van der Elst & Lafarre, *supra* note 17, at 175.

"algorithmic management": Delegating the power to make business decisions to algorithms and other artificial intelligence tools.[110]

The extent to which algorithmic management can affect legal entities' decision-making processes may range from providing simple advisory services to directors and managers—for example, in the form of predictions, recommendations, and other information—to substituting one or more human decision-makers. Algorithms may easily supplant middle managers by setting work shifts, scheduling workers' activities, assigning duties, and monitoring worker performance, as they do in certain gig economy companies, including Amazon and Uber.[111] They could also conveniently replace corporate directors.[112] As incredible as it may seem, this is already a reality. A venture capital firm from Hong Kong, Deep Knowledge Ventures, became famous in 2014 for having nominated a machine-learning algorithm to its board of directors. The algorithm, called "Validating Investment Tool for Advancing Life Science" (or "VITAL"), specializes in investment valuation and, even though it is technically not a board member, it has been given a vote on investment decisions.[113] Other complex algorithms may be capable of making business recommendations and decisions on a more general basis. An example is IBM's artificial intelligence program named "Watson," which, despite its prohibitive cost, might be able to adapt its decisions to changing circumstances.[114]

Although current technology seems relatively far from offering integrated applications for general corporate management,[115] in the near future programmers might develop new machine learning algorithms that

110. The expression "algorithmic management" has also been used in a slightly narrower sense to signify "the use of data and algorithms to hire, direct, monitor, schedule, or discipline workers." For this definition, *see* Rogers, *supra* note 5, at 535, 535 n.19. Rogers recalls that the expression seems to have become popular after being used in Ming Kyung Lee et al., *Working with Machines: The Impact of Algorithmic and Data-Driven Management on Human Workers*, *in* CHI 2015: PROCEEDINGS OF THE 33RD ANNUAL CHI CONFERENCE ON HUMAN FACTORS IN COMPUTING SYSTEMS 1603, 1603 (2015), https://dl.acm.org/doi/pdf/10.1145/2702123.2702548.

111. *See infra* Part III.C.2.a.

112. *See supra* note 21 and accompanying text.

113. Rob Wile, *A Venture Capital Firm Just Named an Algorithm to Its Board of Directors: Here's What It Actually Does*, BUS. INSIDER (May 14, 2014, 1:19 AM), https://www.businessinsider.com.au/vital-named-to-board-2014-5; Jordyn Taylor, *V.C. Firm Names Robot to Board of Directors*, OBSERVER (May 13, 2014, 7:00 AM), https://observer.com/2014/05/v-c-firm-names-robot-to-board-of-directors. The case of VITAL has attracted a great deal of attention also in the legal scholarship. *See, e.g.*, Martin Petrin, *Corporate Management in the Age of AI*, 2019 COLUM. BUS. L. REV. 965, 966–68.

114. Lynn M. LoPucki, *Algorithmic Entities*, 95 WASH. U. L. REV. 887, 900 (2018).

115. Armour & Eindenmüller, *supra* note 57, at 107.

will be able to run simple and not-so-simple businesses at lower costs. One could easily imagine an algorithm that manages a vending machine business,[116] ordering supplies online,[117] tracking inventories, keeping its own accounting, and contracting for workers to periodically fill in the different automats. Algorithms could also conduct more complex businesses, such as a tour operator or a hotel. An algorithm could keep track of tourists' requests, make bookings online, process payments, check availabilities, respond to complaints, and hire agents for all the other tasks that it cannot physically do.[118]

As a result, some commentators have started to question whether such algorithms could actually control business entities with very limited or no human intervention or participation,[119] such as algorithmic subsidiary companies that perform selected and narrow functions,[120] which could be an intermediate step toward fully self-driving corporations and groups. The idea was first put forward by Shawn Bayern, who claimed that U.S. law would permit memberless entities exclusively managed and controlled by algorithms, de facto granting legal personhood to such autonomous systems.[121] Legal constraints to this possibility could come from provisions prohibiting memberless entities or requiring that organizations be managed by natural persons.[122] U.S. limited liability companies (LLC) would, however, be flexible enough to host autonomous systems. Default rules on boards of directors do not prevent algorithmic management and, according to Bayern, state law would also allow LLCs that become memberless over

116. The example of the vending machine is taken from Shawn Bayern, *Of Bitcoins, Independently Wealthy Software, and the Zero-Member LLC*, 108 NW. U. L. REV. 1485, 1494 (2014).

117. Significantly, this task could be carried out with the help of a smart contract. DE FILIPPI & WRIGHT, *supra* note 74, at 82–83.

118. *See* LoPucki, *supra* note 114, at 899.

119. *Cf. id.* at 897 (providing a definition of algorithmic control over an entity).

120. Armour & Eindenmüller, *supra* note 57, at 106–07.

121. Bayern, *supra* note 116, at 1495–98; Shawn Bayern, *The Implications of Modern Business-Entity Law for the Regulation of Autonomous Systems*, 19 STAN. TECH. L. REV. 93, 96, 101–04 (2015). *See generally* Shawn Bayern et al., *Company Law and Autonomous Systems: A Blueprint for Lawyers, Entrepreneurs, and Regulators*, 9 HASTINGS SCI. & TECH. L.J. 135 (2017) (discussing how autonomous systems could inhabit legal entities in different jurisdictions). *See also* DE FILIPPI & WRIGHT, *supra* note 74, at 146–55 (on decentralized autonomous organizations running on blockchain).

122. *See* Stephen M. Bainbridge & M. Todd Henderson, *Boards-R-Us: Reconceptualizing Corporate Boards*, 66 STAN. L. REV. 1051, 1056, 1099–1101 (2014) (supporting, more generally, the reform of mandatory law provisions requiring that boards of directors be comprised of natural persons in order to permit firms to provide professional board services to corporations).

time to continue their operations, at least for a certain period of time, under the exclusive control of an artificially intelligent algorithm.[123] Even if this did not occur, circular shareholdings could achieve a comparable result. A natural or legal person could establish two LLCs, company A and company B, both managed by an artificially intelligent algorithm. If company A were admitted as a member of company B and vice versa, the founder could withdraw from both companies, leaving them in the exclusive control of the autonomous system. In this way, the problem created by a prohibition on memberless entities would be avoided, since each company would technically have one member.[124] According to other scholars, a similar result could be reached with other business entity forms and in different jurisdictions,[125] taking advantage of the possibility to establish algorithmically controlled entities in countries where regulatory standards are low, since they could still do business elsewhere.[126] De facto control could, in any case, be granted to algorithms by employing various expedients, such as contractual provisions delegating all decision-making powers to the algorithm[127] or hiring complacent directors[128] (if, for instance, local law required that the board be comprised of at least one or more natural persons). After all, algorithms already seem better than humans at making many decisions, including selecting prospective corporate directors.[129]

For our purposes, the technicalities regarding how this result may be achieved in practice are not as important as the mere fact that the prospect of a legal entity entirely run and managed by an artificially intelligent algorithm is not so absurd or far-fetched. Leaving aside the accountability issues and policy concerns that autonomous algorithmic entities raise,[130] the sole possibility of delegating management, in whole or in part, to an algorithm

123. Bayern, *supra* note 116, at 1496–97; Bayern, *supra* note 121, at 101–04.

124. Bayern, *supra* note 121, at 104 n.43. *See* LoPucki, *supra* note 114, at 898–99 (contending that, while it is doubtful that LLC statutes permit memberless entities, circular shareholdings could achieve that result).

125. *See* LoPucki, *supra* note 114, at 907–12, 919–24; Bayern et al., *supra* note 121, at 139–53.

126. *Cf.* LoPucki, *supra* note 114, at 926–28.

127. Bayern, *supra* note 121, at 99 (discussing the "process-agreement equivalence principle").

128. LoPucki, *supra* note 114, at 913–18.

129. *See* Isil Erel et al., *Selecting Directors Using Machine Learning* (European Corporate Governance Institute (ECGI) Finance Working Paper No. 605/2019, 2020), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3144080 (showing that algorithms accurately predict director performance).

130. *Cf.* LoPucki, *supra* note 114, at 901–06 (arguing that algorithmic control may pose a threat, amplified by the fact that governments often do not meaningfully regulate the legal entities that algorithms could inhabit).

provokes compelling questions regarding the impact of new technologies on existing corporate roles and functions. Are these new technologies effectively going to deliver on their promise to fundamentally change how shareholders, directors, and managers interact with one another within the corporation? And will they effectively replace directors and managers? To answer these questions, it is crucial to understand the reasons that underlie the current assignment of powers and responsibilities among corporate bodies and to see if and how technology affects them. Parts II and III discuss these aspects.

II. CORPORATE ROLES AND THE BEST DECISION-MAKER PROBLEM

Although there is no widely accepted definition of the term, corporate governance refers to the way corporations are run[131] and, more specifically, to their internal workings. It expresses a view that has taken hold since the 1970s, according to which "the particular balance of power, organizational structure, and decision-making processes *within* the corporation matter deeply for economic and social life."[132] The emphasis is on the distribution of roles, powers, and competences within corporate organizations, as a way to spur corporate behavior toward desired economic and social ends.

Especially over the last decades, stricter rules on board composition, independent directors, executive compensation, and so forth have been deployed as a panacea for all corporate problems. Legal reforms, however, are not the only determinants of corporate governance; they are, in a way, built upon other transformations, which indirectly contribute to affect the internal workings of corporations. The legal scholarship has, for instance, shown that the increased informativeness of stock market prices, together with the widespread adoption of the shareholder value maximization norm, made it possible to empower outsiders with monitoring functions, giving rise to the now ubiquitous board role of the independent director.[133] Similarly, the growth of pension funds and institutional investors has encouraged

131. For a broad definition of corporate governance, comprising "everything that influences the way that a corporation is actually run" and/or that "exercises power over decision-making within a corporation," see JONATHAN R. MACEY, CORPORATE GOVERNANCE: PROMISES KEPT, PROMISES BROKEN 2 (2008).

132. Mariana Pargendler, *The Corporate Governance Obsession*, 42 J. CORP. L. 359, 362–63 (2016). *See generally* Gilson, *supra* note 28 (on the shift from corporate law to corporate governance that has taken hold since the 1970s).

133. Jeffrey N. Gordon, *The Rise of Independent Directors in the United States, 1950–2005: Of Shareholder Value and Stock Market Prices*, 59 STAN. L. REV. 1465 (2007).

greater shareholder empowerment[134] through, for example, proxy access rules and increased disclosure.

This article argues that new technologies have the potential to introduce similar changes in corporate governance by affecting one or more of the fundamental determinants along which corporate law typically distributes power between shareholders, directors, and managers. These include factors that relate to the way decisions must or should be made, such as the timing and frequency of the decisions, the availability of the necessary information, and the costs of deciding, as well as factors that are more deeply connected with the personal features of the decision-makers, such as their incentives, competence, and skills.[135]

The distribution of power within corporate enterprises is not immutable, and corporate governance may be altered when transformations indicate that the best decision-maker on a certain matter has shifted. Shareholders might, for instance, have the best incentives to make a particular decision, but they may lack information or competence, and the costs of acquiring them may be prohibitively high. Accordingly, the optimal allocation of responsibilities might lie in assigning the decision to the board of directors or even to corporate officers, devising governance mechanisms that tie management's incentives to shareholder preferences. If new factors were to lower these costs or make the necessary information or competence more accessible to the shareholders, the conclusion might change. It is, for example, no coincidence that the rise of highly competent institutional investors led to

134. *See* Brian R. Cheffins, *The History of Corporate Governance*, *in* OXFORD HANDBOOK OF CORPORATE GOVERNANCE 46, 52–54 (Douglas Michael Wright et al. eds., 2013).

135. A theory of voting rights in (private) corporations has been put forward by Melvin A. Eisenberg, who offered a taxonomy of the factors that should be considered to determine which matters shareholders would expect to decide, as opposed to those that they would rather leave to management. The distinctions in the text draw from Eisenberg's classifications. *See* Melvin A. Eisenberg, *The Legal Roles of Shareholders and Management in Modern Corporate Decisionmaking*, 57 CALIF. L. REV. 1, 10–11 (1969). A conceptually similar way to look at the issue addressed in Part II is to ask which factors are relevant in establishing whether decision-making authority should be governed by a consensus-based system, assigning decision-making power to the organization's constituents (such as the shareholders), or by authority and fiat, with a central decision-making body that has the power to bind the organization and its members (such as the board of directors, eventually operating through its officers). KENNETH J. ARROW, THE LIMITS OF ORGANIZATION 68-70 (1974). In this respect, the five factors identified in Part II also draw from the observation that "[t]he choice between consensus and authority is driven by three considerations: access to information, member interests and preferences, and severity of collective action problems." Stephen M. Bainbridge, *The Board of Directors*, *in* THE OXFORD HANDBOOK OF CORPORATE LAW AND GOVERNANCE 275, 293 (Jeffrey N. Gordon & Wolf-Georg Ringe eds., 2018) (citing Arrow's work).

calls for greater shareholder empowerment and, in the United States, to the declining influence of Delaware courts in regulating corporations.[136] The reverse is, in any case, also possible. One could imagine that the growing complexity of certain decisions might lead to greater board involvement or to the rise of specialized corporate functions tasked with advisory, investigatory, or even decision-making powers, further removing shareholders from any significant deliberative capacity.

Technology might be precisely the factor leading to such a reshuffling of corporate roles and functions. It has the potential to reduce information asymmetries and collective decision-making costs for shareholders, which have often justified a stronger role for management. It may also help align managerial behavior with shareholder preferences, enabling more direct shareholder control, or even require that managers acquire new competences and skills. Changes need not, and probably will not, be radical. Nevertheless, they will likely alter corporate governance as we know it.

A. The Frequency and Timing of the Decisions

Decision-making power within the corporation is distributed among "a board of directors, which manages the corporation's business; officers, who, as agents of the board, execute its bidding; and shareholders, who elect the board" and decide on fundamental changes and transactions.[137] In modern public corporations, the board of directors mostly performs a monitoring[138] and policy-making role in the interest of the shareholders, delegating operational decisions and day-to-day management to a team of appointed officers.[139] It would, however, be a mistake to think that corporate directors' deliberative capacity is necessarily sporadic or limited. The board's

136. *See* Zohar Goshen & Sharon Hannes, *The Death of Corporate Law*, 94 N.Y.U. L. REV. 263 (2019).

137. Eisenberg, *supra* note 135, at 4.

138. *See* MELVIN A. EISENBERG, THE STRUCTURE OF THE CORPORATION 162–70 (1976) (arguing that the board of directors is uniquely suited to monitor management). *See also* Gordon, *supra* note 133, at 1510–40 (discussing the changing role of corporate boards and the rise of independent directors and the monitoring board).

139. Policy-making here is meant broadly. Corporate directors often do not have the time and ability to craft or influence corporate strategy in the strict sense. *See* EISENBERG, *supra* note 138, at 139–48. However, they sometimes provide advice and counsel to company executives, are involved in certain fundamental decisions, such as mergers, and monitor the implementation of strategies and policies put in place by company executives and employees. *See, e.g.*, Bainbridge, *supra* note 135, at 277–79; Enriques & Zetzsche, *supra* note 16, at 22. *But see* MACEY, *supra* note 131, at 51–68 (challenging the view that directors can at the same time effectively advise and monitor management, and discussing the possibility of board capture by management).

monitoring role entails important decision-making activities, such as nominating executive officers, setting their pay, and voting on major transactions.[140]

This distribution of powers is, first and foremost, justified by the way certain decisions must be made. If decisions must be made frequently, directors and officers are in a better position than shareholders to make them. Officers may do so on a daily basis, devoting most of their efforts and time to the corporation. The board of directors, as the corporation's monitoring and policy-making body, may also act relatively frequently.[141] By contrast, especially in large publicly held corporations, shareholders do not have the time and are not interested in voting on routine matters. When decisions have to be taken swiftly or periodically, calling a meeting of the shareholders might bring undue delays and setbacks, which is why these decisions are usually left to officers and directors.[142]

B. Asymmetries of Information

Clearly, the frequency or speed at which certain decisions must be made cannot be the only relevant circumstance in deciding whether the shareholders have a legitimate expectation to a vote or whether the deliberation is, instead, better left to management. It is, however, an important factor that explains why (routine) business decisions—which typically require repeated action and speed, such as whether to buy a specific piece of machinery or what amount of raw material the company should buy from a particular supplier—by law fall within the powers of managers,[143] under the guidance and supervision of the board of directors.

140. EISENBERG, *supra* note 138, at 158–59, 162–65; Bainbridge & Henderson, *supra* note 122, at 1053. *See* Bainbridge, *supra* note 135, at 283–84 (arguing that the board of directors also performs a managerial function, because even though it reviews proposals made by management it has ultimate responsibility on a variety of basic corporate decisions).

141. This aspect should not be overstated. Board meetings occur more frequently than shareholder meetings, but still a few times a year, which makes it impossible for the board to actually manage the corporation. *See* EISENBERG, *supra* note 138, at 141–43. *See also* Petrin, *supra* note 113, at 973, 975; Bainbridge & Henderson, *supra* note 122, at 1061, 1064–65. It is nevertheless significant that board meetings can be convened more easily than shareholder meetings, if need be. Moreover, the time that directors devote to board service seems to have increased in recent years. Bainbridge, *supra* note 135, at 319, 327.

142. *See, e.g.*, Van der Elst & Lafarre, *supra* note 17, at 168, 170 (observing that the need to provide relevant information to the shareholders before the meeting and the corresponding notice requirements make it impractical to convene the shareholder meeting for actions that have to be taken swiftly).

143. Eisenberg, *supra* note 135, at 10–11.

Other related reasons concern the availability of the relevant information and, more generally, the costs of collective decision-making.[144] Those who are more directly involved in managing the corporation have greater access to information on company operations, which makes them suited to make choices on a daily basis. This does not mean that corporations could not devise disclosure mechanisms aimed at bringing shareholders up to speed. There are, however, compelling reasons not to do so in all circumstances, as well as some practical hurdles. Greater disclosure to a larger number of people might raise, for instance, insider trading concerns. It may also hamper the prospects of closing a deal, if information is circulated too early. This suggests that even assuming that parity of information between shareholders and managers were feasible, it might not be desirable. The resulting asymmetry of information justifies, in turn, a greater decision-making role for corporate management.[145]

C. The Costs of Collective Decision-Making

Large corporate bodies, as shareholder meetings tend to be, also incur significant decision-making costs; the cost of circulating information on the subject matter of the decision, typically covered by the corporation, is only a part of these costs. They include the cost of obtaining information on other shareholders' voting intentions, communicating among shareholders, and coordinating voting behavior in the general meeting.[146] The greater the number of shareholders, the higher these costs are likely to be.[147] Furthermore, collective action itself entails the risk (and thus the cost) of reaching inefficient decisions,[148] which increases with the heterogeneity of the preferences (and possibly the number) of the people involved in the deliberation, as voting outcomes tend to reflect the preferences of the median

144. *See generally* Armour et al., *supra* note 13, at 11–12 (on the information and coordination costs of shareholder meetings).

145. Significantly, the availability of information is one of the factors that contribute to determine shareholder voting efficiency. Michael C. Schouten, *The Mechanisms of Voting Efficiency*, 2010 COLUM. BUS. L. REV. 763, 780–81.

146. *See* Zetzsche, *supra* note 17, at 38–39 (describing the costs of exercising shareholder rights). *See generally* HENRY HANSMANN, THE OWNERSHIP OF ENTERPRISE 41–42 (1996) (on the "costs of the collective choice process").

147. Because the number of the communication channels among shareholders also increases. *See* Bainbridge, *supra* note 135, at 302.

148. *See generally* Schouten, *supra* note 145 (identifying the four mechanisms—informed voting, rational voting, independent voting, and sincere voting—that determine shareholder voting efficiency).

voter instead of those of the average voter.[149] Finally, the average voter could also be wrong.[150] The result is that (large) shareholder meetings entail higher decision-making costs than board meetings or single officers, suggesting that on ordinary matters directors and officers are in fact the best-decision makers within the corporation.

D. Incentives

Another way of looking at how power should be split among corporate bodies is to ask who has the best incentive to decide or who is less prone to opportunistic behaviors and conflicts of interest. For instance, stockholders are said to have the best incentives to decide on structural decisions, such as mergers or liquidations, because their investment is at stake.[151] In contrast, directors might oppose these decisions, especially if they know or expect that they will lose their jobs afterward. Directors also have distorted incentives when it comes to control decisions, such as the appointment and removal of board members, changes in voting rules (e.g., the introduction and regulation of cumulative voting or slate voting), resolutions on the information flows to stockholders, and so forth.[152] Structural and control decisions are not taken frequently and are usually considered and examined over long time spans,[153] enabling the corporation to provide shareholders with the necessary information and to engage the shareholder meeting in the deliberation. Incentives complete the picture, identifying which party might be more self-interested in the specific matter or has, instead, the best motivation to consider the issue.

To be sure, incentives are never clear-cut and thus are seldom decisive for the law. Consider a charter amendment that introduces a class of preferred stock with enhanced financial rights or a new common stock issue. Both changes might have an impact on the value of the preexisting common stock and affect controlling interests within the corporation, which suggests

149. HANSMANN, *supra* note 146, at 39–41. *See* Schouten, *supra* note 145, at 802–05 (explaining how heterogenous preferences may lead to conflicted voting and thus to insincere voting, which undermines voting efficiency). *See also* Bainbridge, *supra* note 135, at 293–94 (on shareholders' heterogenous preferences).

150. The average voter could, in fact, prefer a non-value-maximizing decision. *Cf.* Schouten, *supra* note 145, at 780.

151. *Cf.* Randall S. Thomas & Paul H. Edelman, *The theory and practice of corporate voting at US public companies*, *in* RESEARCH HANDBOOK ON SHAREHOLDER POWER 459, 467 (Jennifer G. Hill & Randall S. Thomas eds., 2015).

152. *See* Eisenberg, *supra* note 135, at 13 (from whom the examples in the text are also drawn).

153. *See id.* (with respect to structural decisions).

that shareholders ought to vote on them.[154] In fact, directors could promote changes in the company's capital structure to favor certain shareholders to the detriment of others, depending on who would be more eager to support their re-election at the next ballot. However, shareholders might also have distorted incentives. They may oppose these changes despite the corporation's need for additional capital in order not to see their financial rights comparatively diminished or their stakes diluted. In contrast, corporate directors could be motivated by the need to provide the company with necessary financial resources and, thus, by a legitimate business concern.

This is why different legal systems devise solutions that, even for structural and control decisions, involve to a certain extent both directors and shareholders. In the examples outlined above, U.S. law grants shareholders the power to amend the articles of incorporation, while the board of directors generally retains the power to propose such amendments. The board of directors may issue new shares, but only within the limits set forth by the law and the corporate charter itself, and thus by the shareholders.[155] In civil law systems, this balance may be reached in different ways, but it also ordinarily requires action by both of the aforementioned corporate constituencies. For example, in the European Union, new issues of stock are subject to a vote in the shareholder meeting, but the board of directors may be authorized in the corporation's charter or by the shareholder meeting to issue new stock within the limits specified in the authorization.[156] The same is true for mergers. Both in the United States and in Europe, mergers require the approval of the board of directors and the shareholders, which each contribute, in different roles and capacities, to the positive outcome of the transaction. The board of directors and its officers negotiate and approve the terms of the merger, making sure that the shareholders receive fair consideration for their ownership interest in the merged enterprise. In turn, shareholders have the final say on the deal, which generally entails an amendment to the company's governing documents.[157]

154. *See* Thomas & Edelman, *supra* note 151, at 467 (arguing that shareholders should vote on issues that relate to, or might have an impact on, the stock price or firm value).

155. Edward Rock et al., *Fundamental Changes*, *in* REINIER KRAAKMAN ET AL., THE ANATOMY OF CORPORATE LAW: A COMPARATIVE AND FUNCTIONAL APPROACH 171, 177, 180–81 (3d ed. 2017). Notably, U.S. case law held that the board of directors may not issue stock for the purpose of reallocating control. Eisenberg, *supra* note 135, at 144. This constraint aims at preventing opportunistic behaviors. Without it, corporate directors could be tempted to alter the capital structure of the corporation in order to grant control to indulgent shareholders.

156. Directive (EU) 2017/1132 of the European Parliament and of the Council of 14 June 2017 relating to certain aspects of company law, 2017 O.J. (L 169) 46, art. 68. *See also* Rock et al., *supra* note 155, at 181.

157. *Cf.* Rock et al., *supra* note 155, at 183–85.

E. Competence and Skills

Interestingly, shared competence of the shareholders and the board may also be understood, if not in terms of incentives, by looking at the skills that are involved in deliberations.[158] To this end, scholars have distinguished between investment skills and business skills.[159] Shareholders are commonly assumed to have the first (or to be able to easily acquire them by hiring an investment advisor), while directors and officers have the latter. After all, the very reason shareholders hire managers is that managers "can run a business more competently than they can, thereby increasing firm value."[160] Accordingly, when a decision involves investment skills, shareholders should be entrusted with the power to make it, while when only business skills are at stake, the decision should rest with the board of directors and its officers. This distinction has, for instance, been invoked to justify, on a theoretical level, why shareholders should vote on a merger or a company liquidation. The idea is that

> the skills involved in formulating a decision to merge with Corporation B or to liquidate Corporation B are similar to the skills involved in formulating a decision to invest in Corporation B, and quite different from the skills needed to formulate an advertising campaign, conduct employee relations, or make steel. Management may or may not have the skill to make such decisions. On the other hand, shareholders … normally will have such skills, even though they may be unequipped to make ordinary or extraordinary business decisions.[161]

Upon closer investigation, however, corporate decisions rarely involve only one set of skills. Shareholders of company A, which is about to merge with company B, may be better equipped to evaluate whether company B is a good investment. The board of directors is, nevertheless, a better judge of

158. Principal-cost theory underscores that competence is a fundamental determinant in the allocation of control rights within firms. *See* Goshen & Squire, *supra* note 24, *passim*.

159. Eisenberg, *supra* note 135, at 10.

160. Goshen & Squire, *supra* note 24, at 785 (also noting that competence is, indeed, "[a] more compelling explanation for the separation of ownership and control" than, for instance, the need to aggregate capital from different investors). As a matter of fact, competence also explains why even wholly owned firms, for which aggregation of capital is not an issue, delegate management to a professional body. *Id.* at 769–70, 772, 780.

161. Eisenberg, *supra* note 135, at 12–13. *Accord* Rock et al., *supra* note 155, at 174. The excerpt included in the text refers to shareholders in privately held corporations, but the same considerations remain valid for publicly held companies as well.

the synergies, economies of scale or scope, and other similar efficiencies that may arise as a result of the merger. Consequently, the law commonly preserves a key role for the board of directors (and its officers) in negotiating and closing such transactions, despite giving decisive weight to the vote of the shareholder meeting.

Moreover, while some investors, such as hedge funds and other activist institutional investors, may also be well-equipped to make or advise on business decisions, other investors may not even have basic investment skills and may need to acquire them—for example, by investing in a fund managed by a professional management company or by hiring a third-party specialist such as an investment consultant. Reality is, as always, more complex than its depictions, but the fundamental distinction between investment skills and business skills helps stress the fact that in large corporations, investors and managers tend to "specialize" in their respective roles.

In short, the law distributes power among corporate bodies based on considerations that concern what decisions must be made and how, including (*i*) the speed and frequency of the decisions; (*i*) the information necessary to decide and who has access to it; (*iii*) the costs inherent in assigning decision-making responsibilities to a collegial body;[162] (*iv*) the decision-makers' incentives and interests; (*v*) their competence and skills. These considerations often point at a specific corporate role as the best decision-maker. Just as often, they justify shared competence and responsibility.

F. Monitoring and Decision-Making

The five factors identified above prove just as important in understanding the allocation of monitoring responsibilities, which also involve decision-making duties. The board of directors monitors management on behalf of the shareholders and, in carrying out this activity, makes the crucial decision of appointing and removing key company executives. Significantly, the board chooses the chief executive officer[163] and decides on executive compensation, which shapes executives' incentives in running the business.

162. Note that the overall cost of collective decision-making may also depend upon the speed and frequency of the decisions and the need to disseminate information. As a consequence, considerations regarding points (*i*)–(*iii*) of the list in the text may partly overlap in practice.

163. EISENBERG, *supra* note 138, at 162–65, 162 n.88 (also observing that besides selecting and dismissing the members of the chief executive's office, the board is generally entrusted with the task of choosing other major officers and, at times, also minor officers).

It is easy to see why the board is entrusted with this task. Selecting key executives does not need to be done on a daily basis or within a short time frame, but the board's costs of collegial decision-making are relatively low compared to the shareholder meeting. The information that is necessary to decide on an appointment is often readily available to the board and does not depend on having close and direct involvement in the business. Most importantly, board members have the necessary skills to evaluate candidates and make the selection, provided that they too often serve or have served as executives for other companies.[164] Similar considerations apply in dismissal decisions. Consider the competence and knowledge required to assess whether low performance is the result of excessive risk-taking or, conversely, whether high performance is mainly obtained by sacrificing necessary investments.[165] Corporate directors seem better equipped than shareholders to make the decision. One could thus very well say that the shareholders hire the board to select and dismiss the chief executive officer and the other executives because company directors are expected to make a more competent choice than them.

More broadly, time availability, the frequency with which monitoring should occur, the coordination costs among principals (which grow with the number of principals involved),[166] the expertise and skills necessary to evaluate agents' actions, and the incentives to take corrective measures are all circumstances that determine who should be in charge of supervision. All of these factors explain why the board's monitoring role is, or should be, more pervasive than shareholders' direct monitoring and why directors are usually said to monitor corporate management "on behalf of" the shareholders. Provided that shareholders do not have the time, desire, and often expertise to monitor corporate management directly,[167] in modern corporations the board of directors serves as a check on managerial action in the interest of the shareholders. Directors have greater access to relevant information, including inside information, and sit on a board that ensures more compact, agile, and smooth decision-making. They have the expertise and skill to evaluate and understand corporate performance, and they might even have comparatively better incentives to monitor the business, due to

164. On all these aspects, *id.* at 163–64.

165. *Cf. id.* at 165.

166. *See* John Armour, Henry Hansmann & Reinier Kraakman, *Agency Problems and Legal Strategies*, *in* REINIER KRAAKMAN ET AL., THE ANATOMY OF CORPORATE LAW: A COMPARATIVE AND FUNCTIONAL APPROACH 29, 30 (3d ed. 2017).

167. Bainbridge, *supra* note 135, at 280. *See* EISENBERG, *supra* note 138, at 167.

reputational constrains and compensation mechanisms that are tied to stock price performance.[168]

To be sure, shareholders perform some monitoring functions as well, which are assisted by the power to appoint and remove the members of the board and by the right to cast their vote on executive compensation, although in an advisory capacity.[169] However, they naturally play a more modest role than corporate directors. This is mainly because, as opposed to the board, they typically do not have the skill and information to evaluate management's business decisions and strategies. They do have an instrument, the stock price, to evaluate whether management is running the business in accordance with their interests, but this only implies that for them the "monitoring decision" ultimately comes down to whether the investment is still sound or not.[170]

III. THE IMPACT OF TECHNOLOGY ON THE DISTRIBUTION OF CORPORATE POWERS AND RESPONSIBILITIES

This Part examines the likely effect of twenty-first-century technologies on corporate governance, arguing that while their impact may be substantial, it is not free of constraints. Big data, algorithms, artificial intelligence, blockchains, and smart contracts may, to various extents, alter the five aforementioned determinants of corporate governance. Technology thus might, on its own, induce some changes in the distribution of powers and responsibilities among corporate constituencies. However, several constraints—including mandatory corporate law—play an important role in enabling more radical transformations.

The combined effect of the new technologies on the five factors discussed in Part II can be summarized as follows. Generally, these technologies enable more frequent and timely decisions, reduce information asymmetries, and curtail the costs of collective decision-making. They facilitate fast and secure communications and interactions. Accordingly, even those corporate bodies, such as the board of directors and the

168. Enriques & Zetzsche, *supra* note 16, at 21. *See* EISENBERG, *supra* note 138, at 162–70 (arguing that the board is particularly suited to monitor management).

169. Dodd-Frank Wall Street Reform and Consumer Protection Act, Pub. L. No. 111-203, § 951, 124 Stat. 1376, 1899 (2010).

170. *Cf.* Thomas & Edelman, *supra* note 151, at 462–63 (arguing that shareholders are the only constituency whose sole certainty of returns is directly tied to changes in the stock price, and that the vote is "almost uniquely useful in providing the shareholders with the ability to monitor the board to insure it protects" their interest to maximize the residual value of the firm as reflected in the stock price).

shareholder meeting, that are not involved in activities that require repeated or speedy action could become more engaged in corporate affairs. This is particularly true for the board of directors, as shareholders might still not have the time to or be interested in taking part in many corporate decisions.

The new technologies also help reduce asymmetries of information and extricate communications from corporate management's exclusive control. Blockchains and smart contracts could, for instance, make corporate documents and data more readily available to shareholders and directors, while at the same time preserving the integrity and authenticity of the information. Technology could therefore contribute to make shareholders and the board more informed about management's conduct, with potential repercussions on the allocation of monitoring responsibilities.

Faster and more secure exchanges via blockchain could also greatly reduce the costs of collective decision-making. Unlike other previous technologies, blockchains ensure tamper-proof communications, the certainty of recordings, and a safe platform for sharing data and information. These advantages are particularly important for the shareholder meeting, which typically incurs in high decision-making costs due to the large number of participants. A limit to the possible improvements in the functioning of the shareholder meeting is, however, that technology cannot homogenize shareholders' preferences, whose heterogeneity conversely raises collective decision-making costs.

On the whole, the impact of the new technologies on the first three dimensions along which corporate law typically distributes power (i.e., the speed and frequency of the decisions; the information necessary to decide and who has access to it; and the costs of collective decision-making) seems to lead to greater shareholder empowerment by facilitating access to information, communications, and voting. Some constraints are, however, immediately apparent. First, despite the possibility of acquiring a more prominent role within the corporation, shareholders might still not be interested in greater engagement. Second, collective decision-making costs can only be reduced through technology, not eliminated. A radical transformation of the role of shareholders is, thus, improbable. In contrast, the board of directors might come out strengthened by the adoption of new technologies, benefiting from wider access to company information, less reliance on information flows originating from executive officers, and greater speed and security in communications. Notably, the two constraints that limit shareholder empowerment do not really apply to the board.

The other two factors that corporate law considers when allocating power among corporate constituencies□namely, incentives and competence or skills□point in the same direction and actually cast further doubt on the

scope and likelihood of technology-enabled shareholder empowerment. Technology does not affect incentives. It cannot make directors and managers less interested in keeping their jobs, nor does it alter shareholder preferences and motivations. Moreover, technological innovations supplement competence and expertise, but they hardly provide these skills to those who lack them. At most, they provide information or recommendations to people who already know how to make appropriate use of both. Incentives and competence will thus continue to shape the distribution of power within corporate enterprises to a non-negligible extent, further limiting the magnitude of the changes that technology can produce in this respect.

Against this general background, this Part examines in greater detail how we can expect the role of shareholders, directors, and managers to change following the widespread adoption of twenty-first-century technologies. Section A addresses the increased ability of shareholders to obtain information, communicate among themselves, and engage in direct monitoring, reducing agency costs and potentially downsizing the board's monitoring role. Section B discusses the likelihood of more direct "shareholder democracy" and the ensuing possibility that shareholders become involved in business decisions, arguing that competence represents a significant constraint to enabling direct shareholder democracy in practice. Section C analyzes the changing role of corporate directors and managers and contends that the board might come out strengthened in its decision-making role, to the detriment of lower-level decision-makers.

Clearly, a broad and logically foregoing potential limit to technologically induced change is the very adoption of new technologies by corporations, which rests in the hands of directors and especially managers.[171] Some of these constituencies might have an incentive to "fight back" against this process or to use technology to further their own interests.[172] For the sake of the analysis, however, Part III assumes that corporations will implement new technologies in their organizations to their fullest potential, as is increasingly the case.

171. Enriques & Zetzsche, *supra* note 16, at 44.

172. *See id.* at 7–8, 31, 42 (arguing that as long as management continues to control the code selection and design process, technology will further its interests within the firm).

A. Shareholders in the Twenty-First Century: Agency Problems and Monitoring

While management often mediates exchanges among shareholders and between shareholders and the corporation by deciding which information should be communicated, to whom, and how, the board of directors serves an intermediary role by monitoring management on behalf of the shareholders. A first set of issues concerns whether with the advent of new technologies corporate management and the board will lose their intermediary function and, in particular, whether shareholders will take over or downsize the board's monitoring of executive officers and managers by engaging in more direct supervision.[173]

1. The Limited Disintermediation of Information Sharing within the Corporation

Corporate management operates as an information intermediary.[174] When shareholders want to provide information to other shareholders in preparation for a meeting, they must go through the corporation and thus through corporate management. Shareholder petitions to the corporation are typically forwarded by management; this offers directors and officers the opportunity to consider each issue in advance and provide a response.[175] Significantly, it is the corporation (and, indirectly, the shareholders) providing the resources in these cases, even when information flows originate not from the shareholders but from directors that wish to obtain proxies.

These constraints might be justified by the need to ensure integrity, parity, and comprehensiveness of information to the benefit of all shareholders, by corporate secrecy reasons, and by the drawbacks of previous technologies. Older technologies automate procedures and safeguard electronic exchanges only imperfectly, and the risk of inaccuracies and tampering while using them remains high. Consequently, although law reforms facilitated direct shareholder communication and distant voting, with some noteworthy exceptions they did not come close to displacing

173. *Id.* at 15–20, 33–42 (presenting and discussing the "board disintermediation hypothesis").

174. Zetzsche, *supra* note 17, at 32.

175. *See id*. *See also* MACEY, *supra* note 131, at 201 (observing that "[b]efore an issue even gets to the shareholders for approval, it must almost always first pass through the board of directors for its approval.").

managers from their intermediary role or to allowing fully virtual shareholder meetings.

The obstacles outlined above might now be partly overcome through blockchains and smart contracts. These technological advances guarantee safer communications and traceable information dissemination, more accurate reporting on corporate matters and events, time-stamping of relevant documents, increased certainty and traceability of corporate actions, and integrity of accounting records.[176] As a result, they are likely to downgrade management's intermediary function and encourage more direct interaction and communication among shareholders and between shareholders and the corporation. Different corporate departments could, for instance, give the shareholders direct access to relevant documents, and shareholder petitions, proposals, proxies and other communications could also be forwarded through blockchains, ensuring parity of information to all authorized participants without the need for management's mediation.

Corporate management is, however, still likely to maintain an intermediary function for two reasons. First, management intervention is needed to verify that shareholders only access the platform for lawful purposes and communications, as well as to ensure the accuracy and comprehensiveness of corporate information made available through the blockchain. There might still be some justification for having management establish whether shared information originating from within the corporation contains relevant, comprehensive, and truthful data. Second, even if it becomes feasible to grant broad access to corporate documents and information without the risk of tampering, hacking, or other manipulation, it might not be desirable or sensible. There is, for example, an enduring need for having management filter confidential corporate information, news, or documents that, if made public, could harm the company's interests.[177] Most importantly, indiscriminate access to all corporate documents, even if not strictly confidential, could hamper the day-to-day management of the corporation and create excessive hurdles for directors and officers.

The most likely advantage of using blockchains and smart contracts to circle information will thus not so much concern the scope or breadth of the disclosure, but rather its timeliness, integrity, and traceability and, to a greater extent, the increased ability of shareholders to share proposals, petitions, and similar communications in a more direct fashion, limiting corporate directors' and officers' advantage of advance consideration.

176. *See supra* Part I.D.

177. *See* Enriques & Zetzsche, *supra* note 16, at 34–35.

2. Direct Shareholder Monitoring and the False Promise of Board Disintermediation

Blockchains and smart contracts are also likely to induce more active shareholder monitoring of the conduct of senior management and other company employees.[178] If technology enables secure document transfers, safe and traceable access to corporate records, and integrity and time-stamping of relevant information, shareholders might demand to obtain more direct knowledge of corporate affairs, relying less on the board's supervision. This might, in turn, foster shareholder activism and even litigation.[179] For example, blockchains and smart contracts could make "executive compensation more easily traceable and quantifiable" for investors,[180] causing shareholders to challenge preexisting compensation arrangements and practices more often than in the past.

Despite these changes, however, there is reason to doubt that corporations will give up the board structure altogether or otherwise strip boards of their monitoring role.[181] Monitoring and policy-making activities require time availability, which shareholders might not have, and frequent engagement, which shareholders might not be willing to undertake.[182] More importantly, they also require business competence and skill, which shareholders typically lack. It is no coincidence that directors' expertise usually mirrors corporate functions (e.g., accounting, compliance) or the areas in which the company operates (e.g., financial services, oil and gas, investments). This is because monitoring agents requires an expert understanding of what the agents do and why they do it; absent such an understanding, shareholders might not be fit for the task.

Technology will not fundamentally change this. Blockchains are not useful for enhancing or providing expertise to those who don't have it and, to be sure, nor are big data and artificial intelligence. Blockchains may help spread information and documents, but they certainly do not provide the

178. *Cf.* Assaf Hamdani et al., *Technological Progress and the Future of the Corporation*, 6(s1) J. BRIT. ACAD. 215, 217, 229–30 (2018) (pointing out that new technologies reduce monitoring costs).

179. *See* Zetzsche, *supra* note 17, at 41 (observing that "[t]o the … extent that information, communication, voting, and review become less expensive, we should expect shareholder activism to rise.").

180. Piazza, *supra* note 91, at 290. On the use of new technologies for executive compensation arrangements, see Hamdani et al., *supra* note 178, at 217, 229; Enriques & Zetzsche, *supra* note 16, at 11–12, 15.

181. *See* Enriques & Zetzsche, *supra* note 16, at 33–42.

182. *See id.* at 35–37 (arguing that passive institutional investors will likely continue to be rationally reticent).

training or expertise that is often required to judge and act upon the information contained in those documents. By the same token, big data and artificial intelligence provide valuable information, advice, and recommendations; however, these are still inputs that require competence to be interpreted, understood, and utilized for decision-making purposes. Artificial intelligence needs experts, or at least competent users, to express its full potential. Consequently, while technology may enable more effective monitoring, it cannot substitute the expertise that monitoring functions often require. Making these instruments available to the shareholders does not equate to providing them with the required knowledge, competence, and expertise. We should thus expect that shareholders will continue to rely to a significant extent on corporate boards for monitoring.

B. Shareholder Empowerment in Business Matters: Lessons from the DAO Case

A second issue is whether new technologies will promote greater shareholder involvement in business or even enable fully decentralized organizations that function under a direct democracy principle—that is, without executives or managers.[183] As anticipated, shareholders typically vote on control and structural decisions, while business decisions are left to the board of directors and its agents. Twenty-first-century innovations, however, facilitate virtual shareholder meetings, potentially leading to shareholder empowerment in business.

Technology will foreseeably allow more frequent and engaged shareholder voting by reducing the costs of collective decision-making.[184] Thanks to improvements in cryptography, blockchains and smart contracts provide a secure tool to share documents and information, trace share transfers, identify who is entitled to participate and vote in shareholder meetings, register proxies and votes, and check compliance with quorums and majority requirements.[185] To be sure, technology does not eliminate all the costs inherent in assigning decision-making responsibilities to a collegial body; factors such as the numerosity and heterogeneity of the preferences of the body's members are likewise crucial.[186] Even if information dissemination and voting procedures become more efficient, the risk (and cost) of reaching inefficient decisions thus remains to some extent, particularly for public companies with a large shareholder base. However, if

183. *See* DE FILIPPI & WRIGHT, *supra* note 74, at 137.
184. Van der Elst & Lafarre, *supra* note 17, at 176.
185. *See supra* Part I.D.
186. *See* HANSMANN, *supra* note 146, at 39–40.

communication means and voting procedures are speedy and secure, they are likely to be used more often. More voting opportunities could, in turn, entail more power for the shareholders in business decisions.[187] Even though the tasks of shareholder meetings are ordinarily established by law, often through mandatory provisions, contract law could introduce some adjustments. The corporation's governing documents could, for instance, provide for enhanced powers to initiate or demand board action or establish shareholder authorizations and advisory votes on business matters, without this necessarily being a violation of corporate law mandatory provisions.[188] For their part, directors and officers might even welcome greater shareholder involvement in business decisions, using it as an argument in support of their choices in case of liability risk. Even if these authorizations and votes were not binding, one can indeed expect corporate management to pay attention to them and conform its actions to their outcome, simply by way of moral suasion.

Nevertheless, it is unlikely that technology will tip the scales in favor of empowering shareholders in business affairs. New technologies do very little to alter shareholder incentives or to supplement or enhance shareholder competence and skills, and this remains a powerful theoretical limit to completely depriving directors and managers of their role.

The case of The Decentralized Autonomous Organization (The DAO),[189] which is often put forward to illustrate how direct shareholder democracy could work in practice through technology,[190] is instead a powerful example of the shortcomings and limits of this idea.

187. *See, e.g.*, DE FILIPPI & WRIGHT, *supra* note 74, at 134 (arguing that "the cost of soliciting shareholder input could decrease to the point where it would become economically feasible for shareholders to assume a greater role in the management of organizations."); Yermack, *supra* note 23, at 23; Enriques & Zetzsche, *supra* note 16, at 18.

188. Possible reforms concern the legal limits to shareholder influence that currently exist in many jurisdictions, including procedural barriers to shareholder petitions or the provision of a minimum share threshold to exercise shareholder rights, which have often been justified by the cost of shareholder voting and engagement. *See generally* Zetzsche, *supra* note 17, at 40. However, these limits are likely to remain in some form, as they are typically also intended to avoid obstructionist behaviors on the part of minority shareholders.

189. *See, e.g.*, Werbach & Cornell, *supra* note 87, at 350–52; Fenwick & Vermeulen, *supra* note 39, at 10. *See generally* DE FILIPPI & WRIGHT, *supra* note 74, at 101–02, 136–55 (on decentralized organizations and The DAO).

190. *See, e.g.*, Reyes, Geslevich Packin & Edwards, *supra* note 92, at 4–5 (defining The DAO as a "leaderless, decentralized venture capital firm" that substituted "code for the directors and officers," and arguing, more generally, at 19, that "DLT [distributed ledger technology] enables business governance structures that are more transparent, more flat, and more participatory," operating "without a centralized authority or agency.").

The DAO was an unincorporated organization run on blockchain technology that ceased operations after having been the victim of a cyberattack and being investigated in the United States by the Securities and Exchange Commission (SEC) for violating public offering rules.[191] Even though blockchains are said to prevent cyberattacks and to produce immutable records that cannot be modified at a later date, The DAO shows that this statement is not absolute, but subject to exceptions under rare circumstances.[192] For our purposes, however, The DAO is an interesting illustration of the extent to which new technologies can actually promote greater investor empowerment (keeping in mind, however, that The DAO did not adopt the corporate form and therefore, mandatory corporate law provisions did not apply to it).

In 2016, The DAO sold a large amount of DAO tokens on the Ethereum blockchain[193] in exchange for a virtual currency named "Ether" for a total value corresponding to approximately $150 million. The DAO was "pure code," managed by German corporation Slock.it. The founder and chief technology officer of Slock.it described The DAO as a code programmed to entirely "automate organizational governance and decision-making."[194] Significantly, The DAO's website specified that the organization existed "simultaneously nowhere and everywhere … operating solely with the steadfast iron will of unstoppable code."[195] Essentially, The DAO raised funds on a blockchain by receiving virtual currency in return for its tokens. The organization's main purpose was to invest these funds in projects brought by contractors. Investors holding DAO tokens were entitled to vote on the contract proposals and shared the "rewards" if the projects were profitable. All voting procedures and corporate governance arrangements were written into code and automated using smart contract technology.[196]

191. A description of The DAO and the results of the investigation are set out in an SEC report. Report of Investigation, Exchange Act Release No. 81207 (July 25, 2017).

192. For a description of the cyberattack and of the following events, when participants in the blockchain managed to "reverse" the hack and obtain the stolen cryptocurrencies back, *see, e.g.*, *id.* at 9–10.

193. On the Ethereum blockchain, *see, e.g.*, DE FILIPPI & WRIGHT, *supra* note 74, at 27–29.

194. Christoph Jentzsch, *Decentralized Autonomous Organization to Automate Governance Final Draft—Under Review* 1, https://lawofthelevel.lexblogplatformthree.com/wp-content/uploads/sites/187/2017/07/WhitePaper-1.pdf (last accessed July 4, 2020).

195. Since The DAO's website is no longer available, the quoted sentence is taken from the report of the SEC, which mentions the content of the website. SEC Release No. 81207, *supra* note 191, at 5.

196. *Id.* at 4–6.

Interestingly, The DAO's website included a messaging platform where invited participants could discuss the organization among themselves.[197] Contractors could submit project proposals to the organization by writing a smart contract, the details of which were published on the blockchain. They usually also provided additional information on their proposal on The DAO's website. The funds raised by The DAO were used to fund the contractors' proposals, provided that they obtained a majority of the votes of DAO token holders. As ordinarily happens for business organizations, the vote of each participant was weighed against the total number of tokens held, in order to ensure proportionality. Not all proposals, however, were put to a vote. A group of people chosen by Slock.it, known as the "curators," were in charge of reviewing the proposals and selecting those that were promising enough to be voted upon. The curators also performed a more general security function, checking, for example, whether the project proposals came from identifiable sources and whether their smart contracts were properly written, which proved important when The DAO came under attack.[198] During the attack, funds were drained from the organization's Ethereum blockchain address to another address in the same blockchain belonging to the hacker. The organization's code managed to freeze the amount deposited in that account for a certain number of days, during which the investors and the curators rewrote the software detailing the rules of the blockchain (the "Ethereum protocol") and transferred the stolen Ethers to a recovery address.[199]

Due perhaps to the attention that the cyberattack brought upon The DAO, the SEC initiated an investigation, which ascertained that the DAO tokens were securities and that, as a result, the organization should have registered them before offering them to the public, absent an applicable exemption.[200] Among the factors that the SEC considered in making the

197. *Id.* at 5.

198. On how project proposals were selected and put to a vote and on the role of the curators, *see id.* at 6–8.

199. *Id.* at 9. Essentially, the curators and the investors enforced a "hard fork," which happens when a majority of participants in a blockchain change the protocol without the consent of all members. This gives rise to a separate chain of blocks, regulated by a different protocol, that shares with the original blockchain some blocks but splits after a certain point in order to enforce new rules. The fork is "hard" when the new rules of the blockchain, and thus the new path taken by it, are incompatible with the original ones. In The DAO case, the hard fork transferred the funds originally raised by the organization, including the stolen ones, to a recovery address. *See* DE FILIPPI & WRIGHT, *supra* note 74, at 24, 188–89 (defining forks as the split of a blockchain in multiple copies due to different causes, and describing The DAO's hard fork); Reyes, Geslevich Packin & Edwards, *supra* note 92, at 6–7 (also on The DAO's hard fork).

200. SEC Release No. 81207, *supra* note 191, at 16.

determination,[201] special attention was given to the significant role assigned to Slock.it and the curators in running the organization. Despite the claim that The DAO was managed entirely by code and in a completely automated fashion, the curators' efforts were deemed essential to the success of the enterprise. Not only did they decide which proposals were put to an investor vote (this included proposals to remove the curators from their office), but they also vetted contractors, presented themselves as experts, and helped investors recover from the cyberattack.[202] In short, even though investors had the final say on the investments that the organization made, the curators behaved and acted as managers, in an entity that resembled in many respects an investment fund run by a management team.

The continued need for a management team by an organization that was purportedly operated "solely with the steadfast iron will of unstoppable code" is particularly significant in understanding the impact of twenty-first-century technologies on corporate governance. It shows that, in all likelihood, shareholders will continue to expect a professional managerial body to undertake some management functions and that direct shareholder democracy is far from becoming a reality.

Besides mandatory corporate law constraints, one reason for this is that shareholders might still not have sufficient time or the desire to decide on all (business) matters,[203] preferring to be in charge only of certain important decisions. In fact, while The DAO's investors held the ultimate responsibility for all investment decisions, they benefited from the vetting and prescreening activity performed by the curators, which permitted them to focus exclusively on the most deserving projects.

Another perhaps more compelling reason is that technology does not help much in providing business competence and skills to those who don't have them.[204] It can solely help them obtain information, which is not quite the same thing. The DAO case was peculiar in this respect: The distinction between investment and business skills was not that relevant, because the

201. The SEC applied the "Howey test," established by the Supreme Court in SEC v. W.J. Howey, Co., 328 U.S. 293 (1946) in order to determine whether a contract is an investment contract and thus a security under Section 2(a)(1) of the Securities Act of 1933. According to the test, a contract is an investment contract if it concerns: (*i*) an investment of money; (*ii*) in a common enterprise; (*iii*) in expectation of profits; (*iv*) solely from the efforts of a third party. The last element of the test underscores that, in order to qualify as an investment contract (and thus as a security), the investment's returns must depend on the managerial efforts of a third party.

202. SEC Release No. 81207, *supra* note 191, at 12–13.

203. *See* DE FILIPPI & WRIGHT, *supra* note 74, at 139–40. *See also* Reyes, Geslevich Packin & Edwards, *supra* note 92, at 26–27.

204. *But cf.* Zetzsche, *supra* note 17, at 42.

business decisions that The DAO had to make were, in essence, investment decisions—that is, whether or not to put money in a certain project. This circumstance alone allowed greater investor empowerment than what could be expected in other scenarios. Indeed, since business and investment decisions almost coincided, The DAO's investors generally had the skills to make (all) business decisions. This is not usually the case, though. In a corporate setting, even though shareholders may demand greater involvement in business matters, they are still likely to opt for some form of delegated management. After all, as The DAO and the investment fund industry show, even when business decisions entail investment skills, a managerial team may serve a useful purpose.

This conclusion can be theoretically explained and understood by resorting to principal-cost theory.[205] Recall that both principals and agents incur competence and conflict costs when exercising control and that optimal governance requires minimizing the sum of all control costs. Competence costs are the costs of honest mistakes due to lack of expertise, skill, or talent. Meanwhile, conflict costs result from self-seeking behaviors and from monitoring efforts that are put in place to limit or prevent such conduct.[206] Principal costs are the main reason that management is usually delegated. They also reveal why investors will continue to "delegate control instead of sharing it collectively,"[207] even in the blockchain era. Under normal circumstances, shareholders will not be able to competently (or cost efficiently) run the business and will hire professional managers instead.

Even when investors have the competence and skill to make business decisions, because they overlap with investment decisions as in The DAO case or for other reasons (and thus principal competence costs are low or zero), delegating some decision-making responsibilities to a professional body might, however, still reduce total control costs. Think of the curators' pre-screening activity of potential investments. Delegating control to the curators presumably cut down the DAO token holders' conflict costs—namely, the costs of self-seeking behaviors and conflicts that may arise among investors due to the heterogeneity of their preferences.[208] Thus, one

205. Goshen & Squire, *supra* note 24.

206. *Id.* at 784.

207. *Id.* at 781. Significantly, when principals are numerous, principal competence costs tend to be higher because any effort made by each principal to make an informed contribution to collective decision-making will most likely be duplicative. *See id.* at 788.

208. *See id.* at 791–93. Principal conflict costs seem to largely, if not entirely, overlap with the costs that in this article have been identified as collective decision-making costs. According to Goshen and Squire, principal conflict costs are one of the main reasons why corporations functioning under a direct democracy principle are never found among widely

can very well expect professional management teams to run the business in whole or in part even when shareholders make a sophisticated and skilled group of potential managers.[209]

It could still be argued that The DAO only proves that executives and managers will continue to be needed, but not that the board will necessarily survive or preserve its role, provided that in The DAO's organization, the management function was performed by a single body, the curators, and not by the usual two-tiered structure of a monitoring board overseeing management. This apparently unique organizational feature follows, however, from the ordinary separation of funds and managers that we typically witness in investment funds,[210] whereby even if the fund has chosen an organizational form that does require a board of directors, the board has in any case a very limited role.[211] The absence in The DAO of a board can hence be understood first and foremost by looking at the specific business (i.e., investment) that the organization undertook. It can also be explained considering that The DAO's investors had unusual competence and skill to evaluate the organization's business decisions and were thus able to perform with a higher than ordinary degree of expertise the monitoring function that is normally entrusted to the board. This, however, is not usually the case. Shareholders typically do not have the time and desire to engage in monitoring, nor they have the competence. Despite allegations to the contrary, neither directors nor officers are thus going to disappear.[212]

held firms. *See also id.* at 797–98. Interestingly, a direct democracy corporation would resemble The DAO in many, if not all, respects.

209. It remains true, however, that "investors who are knowledgeable about business matters will typically delegate less control to managers than those who are uninformed." *Id.* at 789.

210. *See* John Morley, *The Separation of Funds and Managers: A Theory of Investment Fund Structure and Regulation*, 123 YALE L.J. 1228 (2014).

211. The board structure is required for mutual funds by the Investment Company Act but the board's monitoring role on behalf of the shareholders is rendered in practice almost irrelevant by the lack of shareholder activism and the fact that directors can "serve indefinitely without reelection" and "appoint many of their own replacements." *Id.* at 1252. Hedge funds cannot fire the management company and often choose organizational forms that do not even mandate a board. *Id.* at 1232, 1253 (noting, at 1253, that "[t]o the extent that funds do have directors, it is typically because quirks of law in offshore jurisdictions require it."). *See also id.* at 1255 (regarding private equity funds). *See also id.* at 1269–70 (with respect to closed-end funds).

212. *See* Enriques & Zetzsche, *supra* note 16, at 23–42 (challenging the view that corporate boards are going to become obsolete). *See also* Petrin, *supra* note 113, at 1025–29 (providing an account of the view according to which decentralized organizations could make managers obsolete, but concluding, at 1028–29, that "[c]urrently, it seems more likely that technology will revolutionize and improve corporate management rather than lead to its demise.").

Whether or not running a particular business requires mostly business skills or investment skills will tip the balance toward more or less shareholder empowerment and monitoring in the specific case—provided, however, that substantial modifications to the fundamental distribution of powers between shareholders, directors, and managers are generally unlikely. Adjustments may be introduced in the corporation's governing documents, and reforms aimed at accommodating technological innovations may allow greater party autonomy in this respect. In such cases, this article suggests that the distinction between decisions that mostly involve business skills and decisions that mostly involve investment skills is a convenient place to draw the line.

C. Corporate Management in the Twenty-First Century: A New Balance Between Strategic, Supervisory, and Executive Roles

While blockchains and smart contracts might help modernize shareholder meetings, artificial intelligence and algorithms entail greater changes for managerial bodies.[213] Recent examples of machine learning algorithms that provide recommendations and make decisions, such as VITAL or Watson, suggest that humans might not have a monopoly on managerial functions anymore. However, fully autonomous algorithmic entities or even fully algorithmic boards seem a more distant reality.

Current artificial intelligence programs are still far from exhibiting the "general human-level intelligence" or "artificial general intelligence"[214] that would enable them to adjust their decision-making processes to changing circumstances and to apply their "cognition" to a variety of different settings and contexts, as humans do. Moreover, the large amounts of relevant data that are necessary to run machine learning algorithms are not always available, and when they are, there is often a trade-off between access to wide public datasets and their meaningfulness and suitability for firm-specific issues and decisions.[215] This considerably restricts the number of firms that can effectively employ artificial intelligence for decision-making purposes, as well as the type of issues that can be tackled through automated decisions. Some companies may not have the resources to internally develop adequate technological tools, and when they use public data or buy them from third parties, they might not be able to put together appropriate inputs to run machine learning algorithms on idiosyncratic matters of the firm.[216]

213. *See* Möslein, *supra* note 21, at 656–57.
214. *See, e.g.*, Armour & Eindenmüller, *supra* note 57, at 89–90, 96.
215. *Id.* at 97–99.
216. *Id*.

These challenges make it hard to believe that fully autonomous boards or algorithmic entities will spread anytime soon, even in jurisdictions that seem to permit them already.[217] In many other jurisdictions, there is the additional obstacle of statutory provisions that require the appointment of a board of directors comprising (natural) persons.[218] Reforms are unlikely to be undertaken in this respect, at least until policy considerations regarding deterrence and accountability have been convincingly addressed for algorithmic management systems as well.

1. Managerial Accountability in the Era of Artificial Intelligence

Machine learning algorithms and other artificial intelligence tools do not respond to common incentives, only to programming instructions. Current systems of incentives and deterrence, which are tailored to human decision-makers, do not apply to algorithms.[219] Significantly, broad standards of conduct, such as the notions of "diligence," "due care," or "loyalty," are not intelligible for algorithms and cannot even be coded into programming language. These standards, and the liability rules that are built upon them, are inevitably made for human decision-makers. One can hardly see, for instance, how the business judgment rule—which protects directors and officers from second-guessing their business choices if they were not interested in the transaction, they were duly informed, and they exercised their judgment in the good faith effort to advance the corporation's interests—could apply to artificial intelligence alone.[220] Artificial intelligence may be unbiased and uninterested, but this actually depends on coding and programming instructions. The same is true with respect to the availability of the information that is necessary to make such decisions. Again, whether the algorithm is duly informed (i.e., it is working on the proper dataset for the task) depends on a programming choice. Finally, artificial intelligence cannot make any "good faith" effort to advance anyone's interests.[221] The very notion of good faith does not really make sense for algorithms. At most, it does for the flesh-and-blood people who programmed or ran the algorithm. This is because algorithms need well-

217. *See supra* Part I.E and accompanying notes.
218. *See, e.g.*, Möslein, *supra* note 21, at 664–65.
219. *See id.* at 651, 666–67.
220. *See* Petrin, *supra* note 113, at 1016.
221. *See* Armour & Eindenmüller, *supra* note 57, at 108.

defined and specific functioning rules, not broad standards potentially subject to different interpretations.[222]

Strictly speaking, algorithms cannot even be held accountable if they provide bad recommendations or make wrong decisions.[223] They cannot pay damages or make amends. Instead, legal entities (such as the company producing or using the algorithm) and the people running them are needed to enforce any liquidation of damages.[224] As a result, human decision-makers continue to provide crucial accountability when it comes to employing technology for managerial purposes, which the law will not easily abandon without valid alternatives.

2. The Impact of Technology on Organizational Charts and on the Role of the Board

The impact of artificial intelligence on high-level managerial functions may then be better appreciated considering that it will most likely complement, rather than substitute, corporate directors and officers. Besides accountability, the reason is that most of the tasks that corporate executives and directors carry out which often involve situational judgment, flexibility, adaptability, and communication skills are not readily replicable by

222. *Cf.* Joshua A. Kroll et al., *Accountable Algorithms*, 165 U. PA. L. REV. 633, 695 (2017). A similar point has been raised with respect to algorithmic management and the pursuit of corporate purposes. Algorithms "optimize a given goal function" and they do so incredibly effectively. The use of artificial intelligence in decision-making thus "carries the risk that extremely one-sided goals will be pursued with utmost effectiveness." Armour & Eindenmüller, *supra* note 57, at 108–09. Significantly, algorithms do not work well with the broad corporate goals or purposes that often guide managerial decisions today, which may require the balancing of different considerations and interests. Corporate goals must instead be somehow quantifiable and measurable in terms of outcome variables. This in turn "may exacerbate a more general tendency to focus excessively on factors it is possible to quantify such as stock prices." *Id.* at 101. *See also* Petrin, *supra* note 113, at 1020–22 (arguing that, unlike human managers, artificial intelligence could work toward more than one goal at the same time).

223. *See* Gramitto Ricci, *supra* note 16, *passim*.

224. The problem of accountability becomes immediately apparent if one thinks of a fully autonomous algorithmic entity with no human decision-makers and possibly no human members (*see supra* Part I.E). Managerial liability or piercing the corporate veil would not be an option and the only way to recover damages would necessarily depend upon whether the self-driving corporation actually had sufficient assets on its own to ensure damage compensation. Several solutions have been discussed, such as registration or capital requirements, imposing liability on artificial intelligence providers or strict liability on corporations that make use of artificial intelligence, mandatory insurance, etc. On all of these aspects, see Armour & Eindenmüller, *supra* note 57, at 107–08, 110–13. *See also* Petrin, *supra* note 113, at 1013–18.

computers.[225] With this in mind, one can expect that algorithms will streamline and simplify decision-making structures and apparatuses to a considerable extent but not entirely automate them, at least for the majority of firms.

Directors and officers make decisions after company employees perform complex inquiries and fact-finding activities, which often involve information gathering and processing, as well as advice from external experts, advisors, and counsel. It is precisely in relation to these inquiries, preliminary investigations, and advisory services that artificial intelligence can provide its greatest contribution.[226] Artificial intelligence can offer valuable informative support by analyzing large amounts of data, finding correlations and patterns in the datasets, and identifying profitable business strategies and solutions. It may be argued, though, that this is not a new discovery at all. The consequences for corporations may, however, be profound. Not only might demand for external advisory services diminish, but the number of company employees dedicated to these preliminary activities might drop.[227] Automation of these operating tasks suggests that some lower-level managers and employees might disappear from future organizational charts, leaving a good deal of work to the machines.[228]

Competences that have commonly been delegated to executive officers and managers because of the need for particular operating expertise might

225. Corporate directors and officers perform, in fact, a variety of cognitive nonroutine tasks, involving situational judgment, problem-solving skills, complex communications, flexibility and creativity, which cannot be translated into a comprehensive and exhaustive set of rules to be coded in a computer software. With respect to both cognitive and manual nonroutine tasks, computers typically complement, rather than substitute, human labor. *See* David H. Autor, Frank Levy & Richard J. Murnane, *The Skill Content of Recent Technological Change: An Empirical Exploration*, 118 Q.J. ECON. 1279 (2003) (drawing the distinction between routine and nonroutine tasks and showing that computers can more easily substitute workers that carry out the first, but instead typically complement workers that mostly perform the second).

226. Information gathering and processing generally involve routine tasks and are, in fact, easier to automate. *See* Autor, Levy & Murnane, *supra* note 225, at 1284–85. *See also* Autor, *supra* note 62, at 143; Agrawal, Gans & Goldfarb, *supra* note 6, at 16.

227. *See generally* Armour & Eindenmüller, *supra* note 57, at 90, 103 (observing that the use of artificial intelligence will likely mean that fewer people are needed to perform the same tasks, that new decisions will become important, and that agency costs will increasingly relate to fewer strategic areas).

228. *See supra* notes 221 and 225. *See also* Petrin, *supra* note 113, at 971–72, 980, 983–96 (distinguishing between administrative managerial tasks and non-administrative judgment work, and arguing that the former is more susceptible to be completely taken over by artificial intelligence, but that in the future even the latter might be performed to some extent by technology). *But see* Rogers, *supra* note 5, at 553–54 (arguing that automation mostly concerns tasks, not full jobs).

also be automated or shift back to the board of directors (or to inside directors), due to the informational decision-making support provided by technological tools.[229] Directors might be more willing to undertake some higher-level operating responsibilities too, if they can easily obtain the advice and information necessary for the task, and the time and effort that it entails are cut down by automation.

To be sure, modern boards are mostly made up of independent directors who monitor by relying on the information flows put in place by company executives and especially on increased firm-specific public disclosure and market prices.[230] They are thus not necessarily more knowledgeable than investors when it comes to firm-specific information.[231] However, with the additional data, advice, and support provided by artificial intelligence they could become more involved in strategic and operating decisions. Greater availability of decision-making tools not only strengthens the decision-making role of executive board members, to the detriment of lower-level company employees, but it also enables the board as a whole to embrace new responsibilities. Compared to shareholders, outside independent directors retain, after all, the advantage of greater expertise and more frequent interaction with senior management. This makes it easy to predict greater board involvement in company policies and strategies and perhaps even in important operating decisions. Changes in board composition to recruit directors with greater expertise in business or strategic planning might follow suit.[232]

229. A conceptually similar prediction has been advanced by Martin Petrin, according to whom artificial intelligence will likely lead to "fused management": the abolishment of the prevailing two-tiered structure of corporate governance (whereby the board supervises delegated officers and managers) in favor of an all-encompassing management body, combining functions and tasks that are currently performed by the board and by managers. *See* Petrin, *supra* note 113, at 1006–08.

230. *See* Gordon, *supra* note 133, at 1473–1500, 1541–63.

231. Evidence shows, however, that they are generally more knowledgeable than investors, provided that when they trade on the company's stock, they typically outperform the market. *See* Enrichetta Ravina & Paola Sapienza, *What Do Independent Directors Know? Evidence from Their Trading*, 23 REV. FIN. STUD. 962 (2010).

232. *See* Hamdani et al., *supra* note 178, at 230. On the need to adapt board composition and director competence to the opportunities and challenges opened up by technology, see Niccolò Abriani, *La corporate governance nell'era dell'algoritmo. Prolegomeni a uno studio sull'impatto dell'intelligenza artificiale sulla corporate governance*, 2020 IL NUOVO DIRITTO DELLE SOCIETÀ 261, 272–74 (predicting that, in the future, corporate boards could have fewer, more business-oriented members).

a. The Gig Economy, the Changing Role of Production Workers, and the Disappearance of Middle Managers

While artificial intelligence will likely strengthen the highest levels of the organizational chart, the case of middle-level and line-level workers is partly different. Different technologies come in to play, which do not necessarily involve data processing through artificial intelligence, but rather pure algorithmic supervision, management, and control. Algorithms can, in fact, also be used to monitor, organize, and handle internal processes of the firm.[233] For instance, they may be employed to keep track of inventory material, handle customers' orders, organize workers' schedules, provide instructions to workers on how to perform their jobs, hire and lay off workers, and so forth. Robots equipped with sophisticated software may even physically execute some of these tasks, including moving items inside a warehouse or giving customers their change back. Some of these technologies affecting the workforce have already been adopted in large corporate organizations. The observed result is a contraction in the number of certain low- and middle-skilled workers, whose jobs can be performed quite well by technology.[234] As innovations advance, these effects may move up the ladder and affect higher-skilled workers as well.[235] The ongoing technological improvements thus raise the more general question of the actual extent of technologically induced corporate reorganization processes.

Just as not all cognitive and decision-making functions that corporate directors and officers perform can be fully substituted by technology, not all manual tasks can be effectively automated.[236] There is still room for workers

233. *See generally* Sarah O'Connor, *When your boss is an algorithm*, FIN. TIMES (Sept. 8, 2016), https://www.ft.com/content/88fdc58e-754f-11e6-b60a-de4532d5ea35.

234. *See*, *e.g.*, John Armour et al., *Putting technology to good use for society: the role of corporate, competition and tax law*, 6 J. BRIT. ACAD. 285, 305 (2018).

235. *See generally* Autor, *supra* note 62, at 149 (observing that "the occupations that are losing share appear to be increasingly drawn from higher ranks of the occupational distribution."). *See also* Petrin, *supra* note 113, at 1002–03 (predicting that technological development will lead to "fused boards" with fewer members, since artificial intelligence will perform the role previously attributed to some of them).

236. More specifically, only *routine* manual tasks, which can be deterministically specified in a precise and unambiguous set of rules (e.g., moving an object from one side of a room to the other), are easy to automate through computers. The same is true for routine cognitive tasks (e.g., making calculations), which can also be easily automated. By contrast, nonroutine tasks, which include both manual and cognitive activities that humans can perform but whose rules are not sufficiently well understood to be specified in explicit terms, are much more resistant to automation. Examples of these activities include cooking, serving food, and personal care assistance, which may require complex communication abilities, situational judgment and problem-solving skills, as well as manual dexterity. Autor, Levy & Murnane,

who cook, operate storage systems, perform maintenance services or come into contact with customers. Nevertheless, while in highly hierarchical organizations with strong labor unions and job stability (like mid-twentieth century corporations), every employee is partly a manager (in the sense that she can program, administer and manage her own effort and work, including training),[237] this is no longer the case when algorithmic management systems control workers' hires, schedules and performance.[238] Not only does this technology make it is easier to automate some managerial tasks, but it also makes it efficient to divest most production workers of the discretion they had in administering their own skills. As a result, these workers are increasingly confined to purely production roles.[239]

In some cases, algorithmic management systems not only reduce workers' discretion but go so far as to deprive them of their status as employees, turning them into subcontractors. Provided that various technologies enable firms to precisely measure, monitor, and supervise work performance[240] even at a distance and for complex activities, the boundary between employees and independent contractors has often started to disappear.[241]

The gig economy is a powerful example of both forces, as companies in this realm were early adopters of algorithmic management techniques. Indeed, the very expression *gig economy* refers to economic activities carried out by employing a workforce that mostly performs "gigs," "tasks," and not actual "work."[242] This is partly because workers are often split among different jobs and thus devote to the "gig" only limited time,[243] and partly

supra note 225; Autor, *supra* note 62; also cited by Rogers, *supra* note 5, at 554, 559–61 (also providing examples of the shortcomings of robots at performing manual tasks).

237. Daniel Markovits, *How McKinsey Destroyed the Middle Class*, THE ATLANTIC (Feb. 3, 2020), https://www.theatlantic.com/ideas/archive/2020/02/how-mckinsey-destroyed-middle-class/605878/.

238. For the definition of algorithmic management, as used in this paragraph, see *supra* note 110.

239. I am grateful to Daniel Markovits for these observations.

240. *See* Rogers, *supra* note 5, at 562–63 (describing various technologies that enable companies to measure and quantify different aspects of work, process the collected data, and base managerial decisions upon them).

241. *See, e.g.*, *id.* at 549–50, 569–73 (discussing and providing examples of technology-enabled fissuring).

242. *See* Valerio De Stefano, *The Rise of the Just-in-Time Workforce: On-Demand Work, Crowdwork, and Labor Protection in the Gig-Economy*, 37 COMP. LAB. L. & POL'Y J. 471, 477–78 (2016).

243. For example, according to a survey, in 2014 and 2015 most Uber drivers had other jobs in addition to partnering with Uber. More specifically, in 2014, about 31% of the polled drivers worked full time at another job, 30% had another part-time job in addition to

because even full-time workers typically repeat the same tasks and assignments (the same "gigs") over and over again. Famous examples of gig economy companies are Amazon, Uber, and Deliveroo. With some necessary distinctions, all of these companies use algorithms, platforms, apps, location trackers, scanners, and other technologies to manage and monitor their workforce.

Amazon uses algorithms, sensors, and other technologies to monitor warehouse employees in many different respects. The company patented the technology for a wristband that, if implemented, would allow even stricter monitoring on workers, including, for instance, how employees carry out specific tasks, when they take breaks, how long the break is, how they place and move items within the warehouse, and so forth.[244] Significantly, Amazon also sponsored a contest for robots to pick items off of warehouse shelves, but since humans still appear to be better at the task, the company limited itself to using robots that bring the shelves to the employee instead of employing fully robotic arms.[245]

Uber uses an algorithm to match drivers with customers.[246] Drivers use their app to signal availability, accept rides, and obtain payment. The app suggests to the driver the preferred route to the destination and enables Uber to monitor the driver's performance. If the driver receives low customer ratings, refuses too many rides, or underperforms in other respects, Uber can simply refuse the driver access to the platform.

Similarly, Deliveroo uses an algorithm to handle riders' schedules and match each rider to a set of deliveries or a geographic area. Algorithms and apps enable the company to monitor the riders' performance, including how many deliveries they complete, how long each delivery took, whether it was

partnering with Uber, and roughly 38% worked for the company full time. By 2015, these percentages had changed to 52% (drivers working full time at another job), 14% (drivers working part time at another job), 33% (drivers working full time for Uber). Jonathan V. Hall & Alan B. Krueger, *An Analysis of the Labor Market for Uber's Driver-Partners in the United States* 10, 20 (Nat'l Bureau of Econ. Research, Working Paper No. 22843, 2016), https://www.nber.org/papers/w22843.pdf.

244. Ceylan Yeginsu, *If Workers Slack Off, the Wristband Will Know. (And Amazon Has a Patent for It.)*, N.Y. TIMES (Feb. 1, 2018), https://www.nytimes.com/2018/02/01/technology/amazon-wristband-tracking-privacy.html.

245. Noam Scheiber, *Inside an Amazon Warehouse, Robots' Ways Rub Off on Humans*, N.Y. TIMES (July 3, 2019), https://www.nytimes.com/2019/07/03/business/economy/amazon-warehouse-labor-robots.html (describing the operation of Amazon's Staten Island warehouse); Jason Del Rey, *How robots are transforming Amazon warehouse jobs—for better and worse*, VOX (Dec. 11, 2019, 8:00 AM), https://www.vox.com/recode/2019/12/11/20982652/robots-amazon-warehouse-jobs-automation.

246. *See* Lee et al., *supra* note 110 (discussing the main features of the algorithmic management systems employed by Uber and Lyft to provide ride-sharing services).

concluded within the estimated time frame, whether the rider refused deliveries, and so on.[247]

In many cases, an immediately noticeable consequence of the use of these technologies is the rearrangement of the workforce between employees and independent contractors. Gig economy companies tend not to employ their workers but to rely on a wide network of independent contractors[248] who formally retain the power to decide when and how to work, such as whether to accept a ride or a delivery, but are in practice monitored, controlled, and directed as if they were employees.[249] This phenomenon is known as "fissuring."[250] While fissuring also includes cases in which firms actually externalize functions to subcontractors or franchisees, it has brought about pressing calls for labor law reform when it involves a misclassification of employees as independent contractors, as often happens in the gig economy.[251]

Another noteworthy consequence is that these companies enable a modern form of "Taylorism"[252] by breaking down complex activities into different tasks that can either be automated or allocated to low-skilled labor and often try to control working environments such as Amazon's warehouses in order to reduce the need for human flexibility and adaptability.[253] This has progressively led to the downsizing, if not disappearance, of middle-class workers.[254] To be sure, other forces are at play in scaling back the role of middle-class workers within corporate organizations,[255] but technology is speeding up the process as workers no longer enjoy discretion on how to perform their tasks. Technology has increased the distance between actual managers and production workers in the *content* of their assignments. Fewer managers manage, with the help of technology.[256] The rest perform simple, repetitive tasks. The work is broken down into a collection of different gigs, which enables greater standardization and the adoption of internal

247. O'Connor, *supra* note 233.

248. *E.g.*, De Stefano, *supra* note 242, at 478.

249. *Id.* at 491–92, 498.

250. *See generally* DAVID WEIL, THE FISSURED WORKPLACE: WHY WORK BECAME SO BAD FOR SO MANY AND WHAT CAN BE DONE TO IMPROVE IT (2014).

251. *See, e.g.*, Rogers, *supra* note 5, at 569–70, 578.

252. *See id.* at 541, 553 (on "digital Taylorism"). *See also* O'Connor, *supra* note 233.

253. Autor, *supra* note 62, at 155–58.

254. *See id.* at 134–42 (showing that computerization of routine jobs has contributed to employment polarization in the United States).

255. *Cf., e.g.*, Markovits, *supra* note 237.

256. *See* Lee et al., *supra* note 110, at 1603 (observing, with respect to ride-sharing services such as Uber and Lyft, that "[a]lgorithmic management allows a few human managers in each city to oversee hundreds and thousands of drivers on a global scale.").

procedures and rules aimed at making humans and machines work together in a more coordinated fashion.

Among middle-class workers, the contraction of middle managers is probably the most pronounced effect. As the examples of Uber and Deliveroo show, in the gig economy algorithms essentially perform, with limited or no human supervision, two purely managerial functions that have been historically attributed to middle management:[257] (*i*) hiring and layoff decisions, as well as workers' schedules;[258] and (*ii*) monitoring workers' performance.[259] With the spread of these technologies, we can also expect a contraction of middle management in companies that operate in a more "traditional" way. This will have significant implications for corporate law and governance. Fewer upper-level managers and executives can directly manage and monitor a greater fraction of the workforce and will be increasingly called upon to make pivotal decisions. As decision-making power becomes more concentrated, responsibility and salary[260] follow,[261] indicating that human decision-makers must pay close attention to organizational and technological adequacy, information flows, and internal monitoring systems.

3. New (Strategic) Choices for Directors and Managers

The extent of these technologically induced changes will be largely determined by how directors and executives, in their respective roles, will tackle certain emerging tech-governance issues,[262] including those that some scholars have named "CorpTech governance"[263] or "data governance."[264] These involve, first and foremost, the fundamental choice of whether the company should rely on technology and to what extent, as well as the challenge of adapting the company's business model to the opportunities and

257. *Cf.* Rogers, *supra* note 5, at 563 (observing that the tasks that algorithmic management systems automate are mostly managerial, such as "screening of resumés, inventory tracking and ordering, scheduling, workflow organization, oversight, payroll processing, etc.").

258. *See id.* at 564–67 (discussing algorithmic hiring and scheduling).

259. *See id.* at 567–69 (discussing algorithmic monitoring and tasking).

260. On the rising incomes of highly skilled workers, including company executives, see Autor, *supra* note 62, at 142–44; Markovits, *supra* note 237.

261. Armour & Eindenmüller, *supra* note 57, at 90–91, 103–04.

262. Technology and IT have traditionally fallen within the remit of officers and managers, but board involvement is gaining traction. Enriques & Zetzsche, *supra* note 16, at 44–45.

263. *See id. passim*.

264. *See* Armour & Eindenmüller, *supra* note 57, at 90–91, 99–105.

possibilities opened up by technology. Some commentators have advocated for radical changes in corporate governance, such as the abandonment of hierarchical organizational structures in favor of a shift toward platform governance[265] or an "ecosystem" model of organization.[266] Radical upheavals of corporate governance models seem unlikely to become widespread, especially outside of the technology sector or the "platform business."[267] Nevertheless, all companies could, to a greater or lesser extent, adjust their business models to make use of blockchains and smart contracts or take advantage of big data and artificial intelligence applications.

BMW is an interesting example in this regard. Despite its complex, hierarchical organizational structure, it not only embeds new technologies in its cars, but it also uses big data analytics and artificial intelligence for many purposes, including the design, engineering, and production of its vehicles and consumer support services.[268] Variations can be expected across firms and industries, but embracing technology is becoming increasingly a matter of survival for companies.

Most likely, then, the main organizational choice will actually be which corporate functions or jobs should be enhanced or assisted by technology and how this should happen, with possible repercussions on workforce distribution. For corporate executives, however, the key decision will likely concern whether to use artificial intelligence at all and, if so, how to put together sufficiently large sets of relevant data.

Data might be publicly available or bought by third parties but using data analytics based on third-party technology may be helpful only for general inquiries and not for idiosyncratic problems of the firm.[269] The same is true for machine learning and other artificially intelligent algorithms. The technology is usually available for sale, but it generally does not target most corporations' specific needs. Corporate directors and managers will thus

265. *See* Fenwick, McCahery & Vermeulen, *supra* note 30 (arguing that current corporate governance models are failing businesses operating as platforms and suggesting a shift toward "platform governance").

266. Mark Fenwick & Erik P.M. Vermeulen, *The End of the Corporation* 10-26 (European Corporate Governance Institute (ECGI) Law Working Paper No. 482/2019), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3472601.

267. This includes technology firms such as Facebook or Amazon, whose core business is to provide a platform that connects different users for different purposes. A possible classification distinguishes, for instance, between social platforms (e.g., Facebook), exchange platforms (e.g., Amazon), content platforms (e.g., YouTube), software platforms (e.g., Apple iOS), and blockchain platforms (e.g., Ethereum). *See* Fenwick, McCahery & Vermeulen, *supra* note 30, at 175, 177; Fenwick & Vermeulen, *supra* note 266, at 13.

268. Marr, *supra* note 12.

269. Armour & Eindenmüller, *supra* note 57, at 97–99.

have to decide whether it makes economic sense to buy algorithmic technology and data or whether it is better to produce one or the other, or even both, in house.[270] In the latter case, proprietary algorithms running on proprietary datasets might require a restructuring of the "data architecture" of the firm—namely, ensuring that the company has in place adequate procedures to make available to the corporation's decision-making bodies and their technological decision-making aids a large quantity of internal data obtained from customers, suppliers, and so forth.[271] Clearly, the judgment on the opportunity and financial feasibility of such an investment rests with corporate management, as does the responsibility for compliance with privacy laws and regulations.

More generally, current organizational structures need to be adjusted to identify where artificial intelligence and algorithms should be used, to acquire from outside the firm the necessary expertise, to train employees and managers, even at senior levels, and to provide incentives for the proper deployment of technological aids.[272]

4. Tech Committees, Technological Risks, and Monitoring

Algorithmic decision-making is not without its hazards. Even though algorithms are said to be impartial, unbiased, and not subject to distorted incentives,[273] they might produce unbalanced results in practice. To be sure, when this happens it is usually because of biased instructions or data at the outset.[274] Nevertheless, these problems might be difficult to overcome. Continuous monitoring and supervision of the activities performed in whole or in part through artificial intelligence hence becomes critical to ensure quality.

270. *Cf. id.* (also observing that the option of training artificial intelligence on proprietary data is available especially to larger firms).

271. *See id.* at 99–100.

272. *Id.* at 101–03.

273. *See, e.g.*, Hamdani et al., *supra* note 178, at 229. *See generally* Cass R. Sunstein, *Algorithms, Correcting Biases*, 86 SOC. RES. 499 (2019) (showing that algorithms can actually help correct human biases).

274. *See, e.g.*, Surden, *supra* note 60, at 105–07 (discussing the limitations of machine learning programs); Kroll et al., *supra* note 222, at 680–82 (providing examples of situations in which algorithmic decision-making may produce biased, discriminatory, and unfair results); Enriques & Zetzsche, *supra* note 16, at 24–25, 30–31; Petrin, *supra* note 113, at 1005–06 (explaining that algorithms are vulnerable to programmers' inherent biases).

Monitoring the deployment of artificial intelligence falls under the responsibility of directors and officers.[275] When artificial intelligence performs tasks that humans already do well, they have a duty to oversee the result. Even in situations where outcomes are not clear or where artificial intelligence performs tasks that humans are not able to do quite as well, such as when algorithms provide advice and recommendations based on big data, directors and officers maintain a duty to critically evaluate them. The focus of the supervision shifts, however, more toward procedural aspects, such as how the data were assembled or how the code was written.[276]

To accommodate these new monitoring functions, corporate directors and officers might need to acquire greater technical knowledge and expertise.[277] According to some commentators, we will see the rise of "tech committees" in charge of overseeing technological governance arrangements.[278] Importantly, tech committees may also be entrusted with the task of evaluating and managing the technological risks posed by innovation.[279] Imagine a corporation that provides personalized financial advice through a proprietary machine-learning algorithm developed in house. Shortcomings in the algorithm's coding or in the criteria to assemble the data might expose the corporation to significant liability risks. The identification, evaluation, monitoring, and management of those risks requires special knowledge regarding how the algorithm works, how coding instructions are or should be written, how the datasets have been put together, and so forth. The board of directors should be qualified accordingly, through its members or an ad hoc tech committee, and should ensure the presence

275. *See* Möslein, *supra* note 21, at 659–60; Armour & Eindenmüller, *supra* note 57, at 101–03; Petrin, *supra* note 113, at 1013–15.

276. Significantly, human contribution is still important to extract value from big data. Big data analytics involves a multitude of activities on data—such as storage, extraction, filtering, refining, organization, etc.—that are necessary to extract knowledge from them and require expertise and competence. *See* MAGGIOLINO, *supra* note 7, at 37–43, 51 (also observing that the results obtained through big data analytics may be critically evaluated and tested). *See generally* Kroll et al., *supra* note 222 (discussing ways to make algorithmic decision-making more accountable and reviewable ex post).

277. Armour & Eindenmüller, *supra* note 57, at 102, 105, 115; Möslein, *supra* note 21, at 660.

278. *See* Enriques & Zetzsche, *supra* note 16, at 45–47. *See also* Armour & Eindenmüller, *supra* note 57, at 102–03, 115 (supporting the establishment of board committees dedicated to data governance issues).

279. *See* Agrawal, Gans & Goldfarb, *supra* note 6, at 18–20 (providing examples of risks posed by the use of artificial intelligence, including liability risks). Possible areas of oversight include the conflicts of interest inherent in the use of technology for governance purposes. With respect to these conflicts, see Enriques & Zetzsche, *supra* note 16, at 31, 42.

within the corporation of officers, managers, and other employees with the necessary expertise.

This and other similar examples are not science fiction but have already made the front pages of newspapers. IBM, for instance, came under the spotlight when it was discovered that its Watson program for oncology, which had been promoted to hospitals and physicians all over the world, was giving erroneous cancer treatment advice[280] and that it had been benched by one of the hospitals that had been using it, the University of Texas MD Anderson Cancer Center.[281] Apparently, the program had been trained on a limited dataset of hypothetical cases and not on real patients' data; its recommendations thus deviated from approved guidelines.[282] Although no patients were harmed by the incorrect therapeutic treatments suggested by the program, this case sheds light on the need to maintain control over artificial intelligence products and applications, as well as the liability risks that the (mis)use of big data and artificial intelligence can create. Significantly, these risks which often involve privacy considerations, have given rise to dedicated corporate functions that check compliance with the applicable laws and regulations.

5. Corporate Reporting, Compliance, and Information Flows

Monitoring of technological risks is key not only for those enterprises whose business involves providing technological services, as in the examples above, but also for corporations that offer non-technological goods and services but still employ technology as a governance and management tool.[283]

The board of directors is generally responsible for implementing appropriate and effective governance practices, structures, and models. Incorrect use of technological tools that is associated with, or determines, organizational shortcomings ultimately falls under its purview when things

280. Casey Ross & Ike Swetlitz, *IBM's Watson supercomputer recommended 'unsafe and incorrect' cancer treatments, internal documents show*, STATNEWS (July 25, 2018), https://www.statnews.com/wp-content/uploads/2018/09/IBMs-Watson-recommended-unsafe-and-incorrect-cancer-treatments-STAT.pdf.

281. Matthew Herper, *MD Anderson Benches IBM Watson In Setback For Artificial Intelligence In Medicine*, FORBES (Feb. 19, 2017, 3:48 PM), https://www.forbes.com/sites/matthewherper/2017/02/19/md-anderson-benches-ibm-watson-in-setback-for-artificial-intelligence-in-medicine/#400d26ae3774.

282. Ross & Swetlitz, *supra* note 280.

283. *See generally* Kenneth A. Bamberger, *Technologies of Compliance: Risk and Regulation in a Digital Age*, 88 TEX. L. REV. 669 (2010) (discussing technological compliance and risk management systems and their possible shortcomings).

go wrong. A significant example is the deployment of technology for accounting and reporting purposes. Since corporate reporting is the responsibility of directors and managers, if they decide to shift to blockchain accounting, at least some of them should know how to operate blockchains and smart contracts and how to oversee them, and they may be required to obtain specific training for that purpose.[284]

The same is true when technology is used to automate corporate procedures or as a tracking and monitoring device. Corporate management retains the duty to ensure that automated tasks are performed properly and that corporate processes driven by new technologies are able to raise warning signs or circle anomalies when these happen. Ultimately, these and similar responsibilities fall under the general duty of care with which corporate directors and officers must comply at all times. The innovation, as a matter of fact, is not that great.

A final observation is warranted regarding how technology might enhance and strengthen directors' monitoring role. Nonexecutive and independent directors typically obtain information regarding corporate affairs through reports and statements prepared by executive officers,[285] who may have a seat on the board or simply come to inform the board of their activities.[286] Direct access to corporate documents and information by non-executives is often impractical and may even disrupt corporate operations,[287] especially if such access was unplanned. Accordingly, corporations rely on information flows that from the lowest level of the organizational chart reach the board of directors through company executives. The board's dependence on the information flows organized by management creates, however, a number of problems, including the possibility that corporate management presents the information in a biased or unduly favorable way or refrains from providing information to avoid stricter monitoring.[288] Technology may help safeguard the need to ensure systematic and methodic controls without disrupting or obstructing corporate operations by granting more direct access

284. Dai & Vasarhelyi, *supra* note 84, at 17.

285. *See, e.g.*, EISENBERG, *supra* note 138, at 143–44; MACEY, *supra* note 131, at 96; Bainbridge, *supra* note 135, at 284.

286. At least some executive officers have a seat on the board, although the number of executives also serving as directors has decreased over time. *Compare* EISENBERG, *supra* note 138, at 145 (writing, in 1976, that "a substantial number of seats are held by executives themselves"), *with* MACEY, *supra* note 131, at 55 (observing, in 2008, that corporate insiders have very few seats on the boards of U.S. companies). On such changes in board composition, *see* Gordon, *supra* note 133, at 1472–76 (providing data on the rise of independent directors).

287. *Cf.* MACEY, *supra* note 131, at 96.

288. *Id.* at 56, 60–61; Bainbridge, *supra* note 135, at 284.

to information to non-executive and independent directors.[289] Advancements in cryptography and the adoption of blockchains and smart contracts may encourage direct access to corporate documents by people at different levels of the organizational chart, including non-executive directors. This might improve reporting systems and facilitate supervision, making board members less dependent on the information flows received from company executives and officers. The monitoring role of the board of directors may thus be strengthened as a result.

IV. POLICY IMPLICATIONS

Three main policy implications follow from this analysis. The first is the need to preserve the ability of corporations to design their own tech governance structures and to balance the allocation of powers between different corporate constituencies accordingly. The potential benefits and costs of using technology to empower different corporate constituencies vary based on the idiosyncratic features of the firm. Therefore, the general recommendation put forward by principal-cost theory to permit a range of governance structures and refrain from direct regulation of the allocation of control rights[290] also remains valid in the context of technology-driven corporate governance changes.[291] For instance, the benefits that technology-based shareholder empowerment may bring for firms largely depend on the number and competence of the shareholders and on the heterogeneity of their preferences. While it might thus make sense to use blockchains and other technologies to ensure shareholder involvement in business decisions when shareholders have or may easily acquire the necessary expertise, as could be the case for companies with large institutional shareholdings,[292] the same choice might be ill-advised in many other cases. This observation also counsels against the adoption of one-size-fits-all technology-driven corporate governance models that have been enthusiastically supported by some commentators,[293] such as a general shift toward a collaborative

289. Abriani, *supra* note 232, at 273. *But see* Enriques & Zetzsche, *supra* note 16, at 32 (arguing that, "[s]o long as management retains control of the coding, data sources and algorithms used for reporting to a board," technology will not improve information flows).

290. Goshen & Squire, *supra* note 24, 825–26, 828.

291. *See* Enriques & Zetzsche, *supra* note 16, at 47–48.

292. Generally speaking, greater engagement and "collaboration" on the part of institutional investors could help firms acquire valuable expertise and knowledge. *See* Jill E. Fisch & Simone M. Sepe, *Shareholder Collaboration*, 98 TEX. L. REV. 863 (2020) (arguing that collaboration between insiders and institutional investors could be firm-value enhancing by aggregating the partial and complementary information in their possession).

293. *See supra* notes 265 and 266 and accompanying text.

"platform governance" structure. Platform governance might make sense for some but certainly not for all corporate enterprises. Each firm should thus be allowed to make distinctive choices with respect to technology and governance.

There are, however, cases in which the adoption of new technologies should at least be encouraged by lawmakers. I am referring, in particular, to the use of blockchains and smart contracts to run virtual shareholder meetings. In some U.S. states virtual shareholder meetings are prohibited by provisions that require meetings to be held at a physical location.[294] These limits have been often justified by invoking the shortcomings of older technologies, which do not quite provide a secure and effective forum for virtual discussion, information sharing, and voting. Today, blockchains and smart contracts nullify these limits, because they make it possible to almost fully replicate physical meetings in a virtual setting and have the additional advantage of solving some of the problems of traditional shareholder meetings, such as difficulties in shareholder identification, eligibility to vote, proxy issues, and vote counting. This leads to a second, narrower state law policy recommendation, which is to allow virtual shareholder meetings and remove all remaining regulatory barriers to that effect.

Finally, as new technologies can strengthen the role of directors and officers and supplement management in numerous ways, corporations should be nudged to effectively manage and monitor their technological risks and opportunities—for instance, through establishing ad-hoc tech committees of the board and training programs on the use of new technology at the managerial level. As corporate law's duty of care is a blunt weapon to obtain this result, a promising way forward is to introduce disclosure obligations on the internal tech governance arrangements adopted by corporations.[295] These obligations need not be burdensome for disclosing companies, but could be crafted under a comply-or-explain approach, whereby only companies that have made a significant investment in technology for governance purposes would need to disclose which specific organizational controls and procedures they have put in place to that end.

294. As of 2019, 30 U.S. states permitted virtual-only shareholder meetings, 12 other states and the District of Columbia exclusively allowed hybrid meetings (meetings for which remote participation is allowed in connection to a physical gathering), and 8 remaining states required in-person meetings. *See* BROADRIDGE, VIRTUAL SHAREHOLDER MEETINGS. 2019 FACTS AND FIGURES 3 (2020), https://www.broadridge.com/_assets/pdf/broadridge-virtual-shareholder-meetings-2019-facts-and-figures.pdf. Additional constraints to virtual-only shareholder meetings may be set forth in company bylaws, even in states that explicitly allow them.

295. Enriques & Zetzsche, *supra* note 16, at 49–50.

Such a disclosure obligation would enable greater public scrutiny on the use of technology and ideally foster a race to the top toward virtuous governance models.

V. CONCLUSIONS

Common predictions regarding the impact of new technologies on corporations vary from forecasts of completely autonomous organizations run entirely by algorithms to more limited improvements and efficiencies in the workings of corporate bodies and procedures. This article has shown that, while technology probably has the potential to bring about both changes, the most significant and immediate impact will fall somewhere in between and will concern the distribution of powers and competences among corporate bodies.

Twenty-first century technologies are much more capable than previous technologies to affect the fundamental determinants along which corporate law traditionally distributes power between shareholders, directors, and managers. They reduce collective decision-making costs, speed up and automate corporate procedures, ensure safer communications and more accurate reporting, and supplement business competence and skills. These advantages, collectively considered, may shift the balance on who is, on a specific matter, the best decision-maker within the corporation.

Shareholders, especially if knowledgeable in business matters, might come out strengthened from the technological revolution. While it is unlikely that they will remove directors and managers from their roles, they might demand greater involvement in business decisions or more direct access to documents and information for monitoring purposes. The board of directors might, instead, be strengthened in its monitoring and policy-making function, while relying somewhat more on shareholders' indications for business decisions and on new technologies for advice, recommendations, and inquiries, to the detriment of external advisors and lower-level managers and employees.

Although technologically induced changes will likely be firm-specific, the overall result will likely streamline organizational charts and more so hybridize corporate roles and functions so that management, monitoring, and strategy-setting come closer together.[296] Many of these changes are, in practice, enabled by corporate law default provisions that accommodate and embrace technological change. The DAO constitutes, after all, a remarkable example of how contract law can adapt technology to business (or, perhaps,

296. *Cf.* Fenwick & Vermeulen, *supra* note 39, at 13.

make a business out of a technology) and of the risks and challenges that this entails. The issue then becomes to what extent the law should welcome and meet these new demands.